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DEPARTMENT OF ENERGY FISCAL YEARS 1981–82 AUTHORIZATION

(Civilian Applications)

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

NINETY-SIXTH CONGRESS

SECOND SESSION

ON

S. 2332

A BILL TO AUTHORIZE APPROPRIATIONS TO THE DEPARTMENT OF ENERGY FOR CIVILIAN PROGRAMS FOR FISCAL YEAR 1981 AND FISCAL YEAR 1982, AND FOR OTHER PURPOSES

MARCH 17, 20, 24, APRIL 1, AND 23, 1980

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CONTENTS

Hearings: Page
March 17, 1980 1
March 20, 1980 129
March 24, 1980 217
April 1, 1980 391
April 23, 1980 663

Tuesday, Mrch 17, 1980

STATEMENTS

Clusen, Ruth Assistant Secretary for Environment, Department of Energy 65, 67
Fumich, George, Jr., Assistant Secretary for Fossil Energy, Department of Energy 3, 6
Matsunaga, Hon. Spark M., a U.S. Senator from the State of Hawaii 1

THURSDAY, MARCH 20, 1980

STATEMENTS

Church, Hon. Frank, a U.S. Senator from the State of Idaho 129
Miller, Dr. Bennett, Deputy Assistant Secretary for Solar Energy (designate), Department of Energy 171, 181
Savitz, Dr. Maxine, Deputy Assistant Secretary for Conservation, Department of Energy 130, 136

MONDAY, MARCH 24, 1980

STATEMENTS

Davis, Dr. Ruth M. Assistant Secretary, Resource Applications, Department of Energy, accompanied by Dr. Stanley Weiss, Deputy Assistant Secretary for Industrial and Utility Applications and Operations: Rudy Black, Director, Office of Renewable Resources; Bennie DiBona, Director, Division of Geothermal Energy; Fox Parry, Director, Office of Electric Energy Systems; and Bill Voight, Director, Office of Uranium Resources and Enrichment 268, 273
Melcher, Hon. John, a U.S. Senator from the State of Montana 217
Pewitt, Dr. Nelson D., Deputy Director, Office of Energy Research, Department of Energy, accompanied by James Leiss, James Kane, Kathleen Johnson, Dr. John Clarke, and Antoinette Grayson Joseph 218, 223
Sewell, Duane C., Assistant Secretary, Defense Programs, Department of Energy, accompanied by Richard Schriever, Deputy Director, Office of Inertial Fusion; and Eugene Beckett, Department of Energy 352, 357

TUESDAY, APRIL 1, 1980

STATEMENTS

Agnew, Dr. Harold M., president, General Atomic Co., San Diego, Calif 525, 530
Bagge, Carl E., president, National Coal Association, Washington, D.C., accompanied by Dr. Joseph J. Yancik, vice president of research 411, 417
Boyer, Dr. Vincent, senior vice president, Philadelphia Electric Co., Philadelphia, Pa 587, 589

Page

Colby, Dr. L. James Jr., senior vice president of Allied Chemical Corp., Morristown, N.J., accompanied by Dr. James A. Buckham, executive vice president of Allied-General Nuclear Services 392, 395
Davis, Ralph M. past chairman, Puget Sound Power & Light Co., Bellevue, Wash 596, 598
Fri, Robert W., executive director, Electric Utilities Fuel Cell Users Group, Washington, D.C. 653
Gibbs, D. Clark, director, nuclear activities, Middle South Utilities, New Orleans, La 455
Hollings, Hon. Ernest F., a U.S. Senator from the State of South Carolina 392
Hunter, Dr. Oscar B., Jr., M.D., director, Hunter Memorial Laboratory, Washington, D.C., representing the Society of Nuclear Medicine, New York, N.Y., accompanied by Henry Ernstall, executive director of the Society of Nuclear Medicine 644, 646
Lawrence, Dr. L. R., Jr., director Technical Development, Mechancial Technology, Inc., Latham, N.Y 473, 478
Matsunaga, Hon. Spark M., a U.S. Senator from the State of Hawaii 391
Rosenberg, Dr. Robert B., executive vice president, Gas Research Institute, Chicago, Ill 610, 614
Schora, Dr. Frank C., senior vice president, Institute of Gas Technology, Chicago, Ill 625, 629
Smith, Sherwook H., president, Carolina Power & Light Co., Raleigh, N.C., accompanied by Dr. D. Clark Gibbs, director nuclear activities, Middle South Utilities, New Orleans, La 431, 437
Wolff, Benjamin L., executive director, American Wind Energy Association, Washington, D.C. 503

WEDNESDAY, APRIL 23, 1980

STATEMENTS

Church, Hon. Frank, a U.S. Senator from the State of Idaho 663
Cunningham, Hon. George W., Assistant Secretary for Nuclear Energy, Department of Energy, acccompanied by Robert L. Ferguson, Deputy Assistant Secretary for Nuclear Energy Programs; and Sheldon Meyers, Deputy Assistant Secretary for Nuclear Waste Management 665, 668, 676

APPENDIXES

APPENDIX I

Questions submitted to the Department of Energy and responses:

Maxine Savitz 744
Bennett Miller 753

APPENDIX II

Additional statements submitted for the record 791

DEPARTMENT OF ENERGY FISCAL YEARS 1981-82 AUTHORIZATION

(Civilian Applications)

TUESDAY, MARCH 17, 1980

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
OF THE COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:30 p.m., in room 3110, Dirksen Office Building, Hon. Spark M. Matsunaga, presiding.

Present: Senators Matsunaga, Bumpers, Melcher, and Bellmon.

Also present: Willis Smith, professional staff member.

OPENING STATEMENT OF HON. SPARK M. MATSUNAGA, A U.S. SENATOR FROM THE STATE OF HAWAII

Senator MATSUNAGA. The subcommittee will come to order.

I wish to welcome one and all to the first fiscal year 1981 budget authorization hearing of the Subcommittee on Energy Research and Development. Today's hearing will examine the budget requests for the fossil energy program and the environmental program at the Department of Energy.

Our witnesses today are Mr. George Fumich, the Assistant Secretary for Fossil Energy and Mrs. Ruth Clusen, the Assistant Secretary for Environment.

Last year our national will was again aroused by the severe energy shocks which the Nation received. As a result, the conference committee on the bill S. 932 has recently reached agreement on a national policy for the development of synthetic fuels from fossil energy resources.

This is a major step forward in our Nation's drive to demonstrate the economic and environmental acceptability of these alternative fuels. A significant amount of taxpayers' money will be spent to accomplish this goal.

There are many other fossil energy technologies and resources which can be utilized by this country which can contribute greatly to free us from energy dependency. For example, our Nation possesses an abundance of coal, more than any other nation on Earth.

However, not all of this coal can be reached by conventional or even unconventional mining methods. A large part of this resource can be tapped by underground coal gasification. This is a program which the Department of Energy and its predecessor has pursued, initially without industry interest. It now appears that industry is interested in committing significant private funding to develop this technology for tapping coal energy in the ground.

In addition, this Nation contains vast reservoirs of natural gas. Until only recently, however, it has been uneconomical to try to drill for this gas. Now, with the development of new hydrofracting techniques and increased prices for natural gas, these resources are becoming attractive. However, not enough is known about how the resources can be tapped or the geology of the reservoirs.

In addition, a number of nonsynthetic fuels technologies could significantly affect our energy supply in the very near term. To make synthetic fuels we must mine the coal first. Therefore, increasing the productivity rate of advanced mining techniques and machinery is clearly necessary for increased utilization of coal.

Technologies such as fuels cells, which are much more efficient than conventional electrical generating devices, can utilize our precious natural gas resources and expensive synthetic fuels in a much more economic and environmentally acceptable manner.

The administration request for coal research and development shows a significant increase over last year's request. However, the greatest portion of the increase is for funding synthetic fuel demonstration plants. When this money is subtracted from the budget, we note that almost all fossil energy programs for research and development were significantly cut below last year's levels. I have noted that one of the programs which was increased is the budget for salaries.

Another budgetary issue which we wish to hear about in testimony this morning is the Department's proposal to utilize $50 million in windfall profit tax revenues for energy research and development.

Closely tied to the fossil energy program at DOE is the necessity to understand the environmental impact from increased coal usage, from new methods for extracting oil and natural gas, and from alternative energy sources. The Assistant Secretary for Environment oversees and directs the environmental research programs and contributes to the development of environmental policy within the Department of Energy.

With the Nation's new emphasis on synthetic fuels and the increased usage of coal, the environment budget shows an increase for environmental research on coal usage of 25 percent.

It is also important to note that the environmental program at DOE which examines inexhaustible energy sources, such as solar and geothermal, has an increase of 17 percent. Solar, geothermal and conservation are viewed as having a lesser environmental impact than coal and other fossil fuels.

However, it is very important that we do not take lightly our utilization of these resources. It is important to understand the environmental impacts of every energy form.

Two environmental issues have been the subject of great debate recently because of their global consequences. The combustion of all fossil fuels results in the production of carbon dioxide. Scientists have been examining the possible results from increased combustion of these fossil fuels and many have reached the conclusion that there may be significant adverse effects to the world's climate.

DOE has recently announced a carbon dioxide research program which will span several agencies in the Federal Government.

Another problem with global consequences is the production of acid rain. When the Senate passed the synthetic fuels bill, S. 932, the acid rain issue was raised. The Senate then adopted an amendment to require that a similar multiagency study be conducted about this phenomenon which many feel is connected to increased combustion of fossil fuels.

We look forward to hearing from you, Mr. Secretary, and about the effects of your efforts in fossil energy and the environment. We would be very happy now, Mr. Secretary, to hear from you.

STATEMENT OF GEORGE FUMICH, JR., ASSISTANT SECRETARY FOR FOSSIL ENERGY, DEPARTMENT OF ENERGY

Mr. **Fumich**. Thank you, Mr. Chairman. I appreciate your opening statement and I concur with the concerns you mention in regards to optimizing of the utilization of fossil fuels in our economy.

As you will notice by this thickness of the statement that I have here, we have erred on the side of assuring that you have sufficient information about our program. I do not intend to try to go through this statement in my remarks. I will let you all have your option either I will highlight the last years' accomplishments or, if you think time is of the essence, we can immediately proceed with questions and answers and submit this statement for the record.

Senator **Matsunaga**. Your full statement will appear in the record. Incidentally, I must apologize, I forgot that we have Senator Melcher present. Do you have an opening statement, Senator Melcher?

Senator **Melcher**. No, I don't, thank you very much, Senator.

Senator **Matsunaga**. Then we would appreciate your summarizing your statement and point out the highlights as you feel your statement ought to be highlighted.

Mr. **Fumich**. The theme of my statement is the following: We all recognize that we have a liquid fuel crisis in this country, but we do not have an energy crisis. The unfortunate part of the situation is that our least abundant resource in this country, petroleum, provides the greatest amount of energy. In other words, petroleum reserves are below 10 percent of this country's total energy reserves, yet petroleum furnishes approximately 50 percent of our energy consumption today.

On the other side of the hourglass, so to speak, we have coal which, depending on the study or report that you want to listen to, amounts to a minimum of about 70 percent of our reserves up to a figure of about 85 or 90 percent. Yet this tremendous resource only furnishes approximately 18 percent of our energy consumed today.

I think the main purpose of what we really have to accomplish in the fossil energy program, we have to turn the situation around. In other words, we have to lean more on our most abundant resource and take something away from our dependence on oil. This is not going to be very easy, this is not going to be accomplished tomorrow.

One of the main reasons that coal is not utilized more in the country today is because of its cleanliness. We all know that coal has barnacles, so to speak. It's a solid and we have problems transporting it great distances. It's dirty and for that reason many people have preferred not to use it if they can use oil or gas. This is what has happened in the last 30 years in this country. Coal has certain pollutants that we have to recognize and have to eliminate. These are the problems we have to deal with. This is what our program does.

I would say that the primary focus of all of our coal research is to try to turn this consumption situation around. In other words, take the pollutants out of the coal and develop better technologies for its use.

There are basically three ways to do this. You can do this before combustion, during combustion, or after combustion. Alternatively coal can be converted into a liquid or into a gas. The main thrust of our coal program is to make sure that we can use coal directly because that is the quickest way, in my estimation, that we can increase the 18 percent of total energy consumption from coal up to a much larger figure. This is what we have to do.

We have to make sure that we can burn coal directly so we can greatly increase its use. Over 90 percent of our coal is burned directly in this country today. Even if we have a very strong synthetic fuels program even by the year 2000, most of the coal consumed in this country will still be burned directly.

In other words, direct utilization will remain our greatest coal usage. It just means that we are really going to have to work in this particular area.

Our second program focus is to increase liquids production as far as we can. We can do that in two or three different ways. First, we can convert coal to a liquid. As you mentioned, about 40 percent of the FE budget is in coal liquefaction projects. We consider this area very critical and consider that our priority is in the right place.

As another source of increased energy supply, we can also enhance our oil recovery. At the present time, we only recover about 30 percent of the oil that we find in a deposit in this country. Two-thirds of the oil discovered still remains underground. An improvement of even a few percentage points of recovery would mean billions of barrels of additional supply.

This is the reason we have enhanced our recovery programs, both in light oil which represents a resource of about 230 billion barrels and in heavy oil which represents about 70 billion barrels of resource. Both together amount to the 300 billion barrel target that we have.

We also have about 600 billion barrels equivalent in oil shale in this country. That figure would approximate the richness in the Piceance Basin of Colorado and also areas in Wyoming and Utah that can yield about 25-plus gallons for each ton of that resource.

We also have about 30 billion barrels of tar sands in this country. So, if we can convert these resources into liquid fuels, we can pretty quickly in some cases and a little farther down the road in others, address domestically what should be done in liquid fuels.

That is one side of the equation. The other side is that almost 3 million barrels a day of petroleum is used in stationary applications in this country today. Naturally, if we displace these liquids with some other fuel to be utilized in the same application, we can use the displaced oil in the transportation market where it is critical. This is another thing that must be done; to accomplish this, the administration just recently proposed its oil backout program to the Hill.

A third part of our program, equally important, is increasing the energy conversion efficiency of technologies. I can give you a specific instance. Let's take magnetohydrodynamics (MHD), for example. If we can use less coal and with the new technology to produce an equivalent amount of electricity we are doing two things. By using less coal, we put less trauma and load on the mining and transportation systems and also put less pollution in the air. If the coal to electricity energy conversion process is more efficient, it produces less pollutants per ton of coal. You have a double positive there and that is what we are working toward.

By increasing our efficiency of utilization in conversion and by consuming less coal, whether a few percentage points or by 10, 15, or 20 percentage points, we produce more net energy for less raw energy resource on the front end.

This increased conversion efficiency means we extend our coal supplies and at the same time put less of a load on the different systems that must be augmented to utilize these particular energy resources. This is one of the main justifications for this particular program and this squarely addresses the two concerns you mentioned in your opening statement, acid rain and the CO_2 problem. By using less coal with increased efficiency and by cleaning the coal more effectively on the production end, you start resolving these problems immediately. We will be using more energy in the future but if we use energy more effectively on the front end and clean up the combustion products more, this will help to address these particular environmental problems.

We can't say that this will be the complete solution. What we must do immediately is to use more coal cleaning before the coal gets to the utility. Downstream, in time, by increasing the efficiency of our coal utilization technology, we will be making greater inroads into the solution of these pollution problems.

This is what I would say is the theme of my opening statement here today.

[The prepared statement of Mr. Fumich follows:]

STATEMENT SUBMITTED FOR

THE RECORD

BY

GEORGE FUMICH, JR.
ASSISTANT SECRETARY FOR
FOSSIL ENERGY
U.S. DEPARTMENT OF ENERGY

BEFORE THE

SUBCOMMITTEE ON ENERGY
RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

MARCH 17, 1980

Mr. Chairman and Members of the Committee:

I am pleased to appear before you this year, particularly as the Department of Energy's first Assistant Secretary for Fossil Energy, and to present what we believe is a strong fossil energy budget for fiscal year 1981.

As Members of the Committee may know, since we appeared before you last year, the Department has been restructured with the fossil energy research, development and demonstration programs being elevated to the level of an Assistant Secretary.

Mr. Chairman, the budget we will be discussing today along with this organizational realignment reflects the strong commitment the Administration places on the role of fossil energy in this Nation's energy future. It reflects the realization that fossil energy resources — which today supply almost 94 percent of the country's energy — must continue to provide the dominant share of the Nation's fuel needs well into the twenty-first century.

This need to place increasing reliance on the domestic energy supplies we have in abundance has been reinforced by the recent impact of international events. The instability in the Middle East, the price uncertainty within OPEC, the increasingly frequent use of oil as a measure of political influence — all directly affect our ability to meet our energy needs and to maintain our economic and national security.

Removing our dependency on unreliable energy sources will require a wide variety of complementary efforts in both fossil and non-fossil technologies. Energy conservation must continue to be vigorously pursued, energy pricing and regulatory policies must be oriented to allow market forces to play increasingly greater roles, and improved technology must be developed and deployed to provide fuels in a form that can ensure our continued economic growth and prosperity while minimizing adverse impacts on the environment.

The role of fossil energy technology is critical in this major national shift toward more abundant domestic fuel resources.

Oil imports can be reduced by directly substituting coal for oil or gas in utility or industrial boilers, but to achieve this conversion may require a significant portion of existing equipment to be replaced and new pollution control equipment may be required. Therefore, new direct coal burning equipment and environmental control technology must be developed to meet regulatory and provide the basis for incentive programs designed to encourage such conversion.

Liquid fuels are required for transportation and for stationary applications where direct combustion of coal is either physically impossible (lack of adequate space), environmentally unacceptable (sensitive urban areas), or economically impractical (residential, commercial, and small industrial applications).

Converting coal and oil shale into gas or liquid products can help meet these needs. But while a variety of technologies are commercially available today and will be deployed under the financial incentives to be provided by the Energy Security Corporation, new technology will be needed to ensure the widest range of applications and resource utilization along with improvements in efficiency, economics and environmental acceptability.

As increased domestic production of oil and gas is encouraged through regulatory, pricing and other financial incentives, it is important to avoid the widespread use of less efficient technology that is economically attractive in the near term but could reduce ultimate recovery. That is why technology development in enhanced oil and gas recovery for high risk and high payoff processes continues to be important even as other incentives begin to play a greater role.

Therefore, we see as our primary mission accelerating the development of technologies that will:

- o reduce petroleum imports as rapidly as possible by substituting coal through:
    - environmentally-acceptable combustion in applications which today depend heavily on oil;
    - conversion to clean synthetic liquids and gases using both eastern and western coals.
- o increase domestic production of coal, and production of oil and gas as well as oil from shale and tar sands;
- o allow more efficient, environmentally acceptable and economically attractive use of fossil energy resources so that fuel use and corresponding environmental impacts can be reduced without adversely affecting economic growth.

We believe our Nation has sufficient fossil fuel reserves to permit us to regain our energy security without unduly disruptive impacts on either the economy or the environment if we move aggressively without delay.

Therefore, our primary emphasis is on coal, our largest fossil energy resource and the one that can play an increasingly significant role immediately. Almost 90 percent of the coal we use today is burned directly, and we have every reason to believe that, at least for the rest of this century, the great majority of coal we use in this country will continue to be burned directly. However, increasingly stringent environmental regulations must be observed in coal combustion, and this could be prohibitively expensive unless technology development in new combustion and clean-up techniques is successful.

One of our most urgent national needs is the development of liquid fuels, for both transportation and petrochemical applications. As I have mentioned, some synthetic fuel technologies are ready for commercial deployment today, and several new techniques are approaching the commercial threshold. This Committee has been instrumental in the progression of these technologies from the laboratory through increasingly larger scales of development, and in FY 1981, the start of construction of several large-scale synthetic fuel facilities will be solid proof that we are today seeing the fruits of a long and often arduous development process.

Over $420 million, or approximately 40 percent of our request for funding in the coal area would go for the construction of these major facilities in FY 1981. This is a clear signal that the Administration is committed to providing the large sums of funding that will be necessary to complete the final steps in the development process and to ready these technologies for commercial deployment. In addition, we are continuing to conduct work on more advanced liquefaction and gasification processes that promise significant cost and efficiency improvements further into the future.

Concurrent with these efforts, we are also working on technologies that use coal more efficiently, especially in electric power generation, since this is another way of reducing the delivered cost of coal-fired energy and reducing the environmental impact of coal production and transportation. Work in this area includes magnetohydrodynamics (MHD), fuel cells, and heat engines and heat recovery.

The final focus of the Fossil Energy Program is on extending our supply of petroleum and natural gas by developing new supply technologies to permit the economic extraction of more of our domestic oil and gas sources, by developing our oil shale and tar sand resources and by assisting in the development of technologies that can tap these energy reserves more efficiently and with less environmental intrusion.

READEX FICHE

In reviewing this budget submission, it is important to keep in mind that the importance we place on a technology cannot be judged solely by the budget figure placed beside it. While there are several key technologies whose technical and economic uncertainties are currently too great for substantial private sector investment -- these are programs for which direct federal support is justified -- there are other technologies that are today becoming nearly competitive and the Administration's support is better exemplified in areas outside of research and development.

ORGANIZATION

Office of the Assistant Secretary for Fossil Energy

The elevation of the Fossil Energy office within the Department has resulted in a substantial restructuring of the major program and management areas. As shown in the accompanying chart, the organization as proposed consists of four line offices, five Technology Centers (ETCs), and two Mining Technology Centers.

The management concept employed is one of matrix management and team participation for more effective and efficient operation. Under the DOE policy of decentralization of project management to the field organizations, two distinct functional roles have been delineated: (1) Headquarters is responsible for developing overall policy and programs; (2) field organizations, including operations offices and national laboratories, are responsible for implementing fossil projects and technology base activities.

Reading from left to right across the organization chart, the Program Director for Project Management is responsible for the management of major systems acquisitions and major projects including their design, construction, checkout and operation. This office will also maintain the Fossil Energy liaison with the Office of the Assistant Secretary for Resource Applications.

The Fossil Energy organization is supported by an Office of Management, with the Deputy Assistant Secretary for Management responsible for budget and administrative functions as well as institutional relations and field coordination.

The Deputy Assistant Secretary for Coal Technology directs and manages the research, and technology development program involving all aspects of coal technology, including synthetic fuel processes for conversion of coal into liquids and gases. The office is divided into four major program areas: coal utilization, coal processing, mining and MHD.

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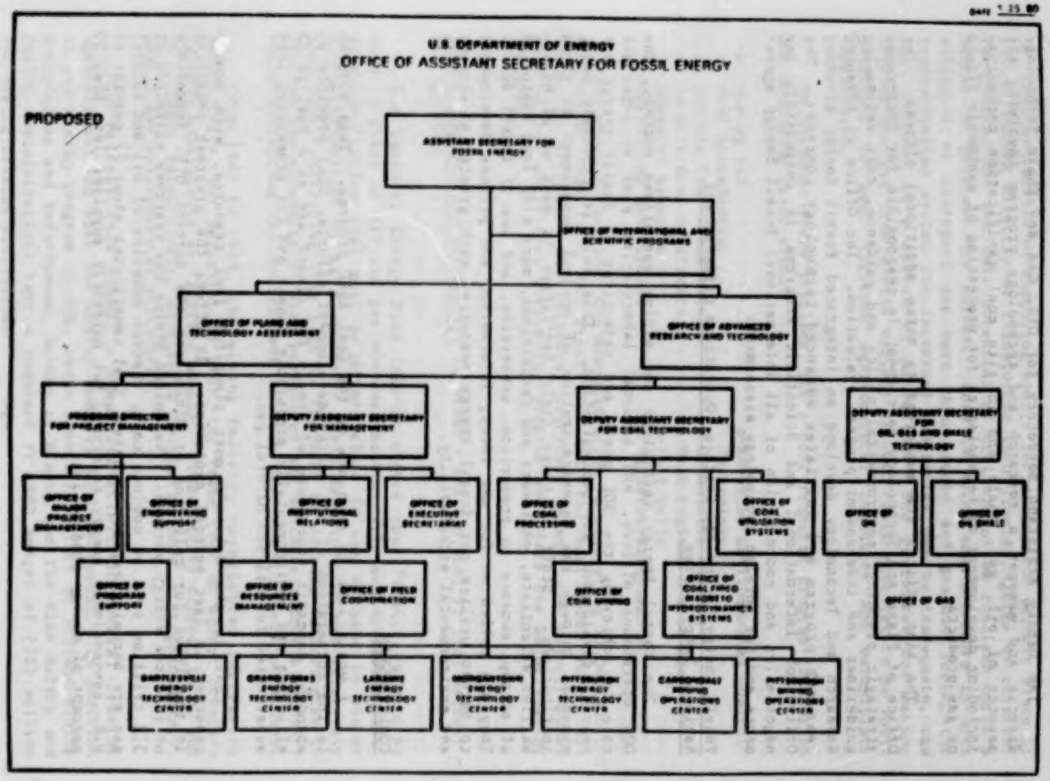
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OFFICE OF ASSISTANT SECRETARY FOR FOSSIL ENERGY
PROPOSED
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OFFICE OF INTERNATIONAL AND SCIENTIFIC PROGRAMS
OFFICE OF PLANS AND TECHNOLOGY ASSESSMENT
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY
PROGRAM DIRECTOR FOR PROJECT MANAGEMENT
DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT
DEPUTY ASSISTANT SECRETARY FOR COAL TECHNOLOGY
DEPUTY ASSISTANT SECRETARY FOR OIL, GAS AND SHALE TECHNOLOGY
OFFICE OF MAJOR PROJECT MANAGEMENT
OFFICE OF ENGINEERING SUPPORT
OFFICE OF PROGRAM SUPPORT
OFFICE OF INSTITUTIONAL RELATIONS
OFFICE OF EXECUTIVE SECRETARIAT
OFFICE OF RESOURCES MANAGEMENT
OFFICE OF FIELD COORDINATION
OFFICE OF COAL PROCESSING
OFFICE OF COAL UTILIZATION SYSTEMS
OFFICE OF COAL MINING
OFFICE OF COAL FIRED MAGNETO HYDRODYNAMICS SYSTEMS
OFFICE OF OIL
OFFICE OF OIL SHALE
OFFICE OF GAS
BARTLESVILLE ENERGY TECHNOLOGY CENTER
GRAND FORKS ENERGY TECHNOLOGY CENTER
LARAMIE ENERGY TECHNOLOGY CENTER
MORGANTOWN ENERGY TECHNOLOGY CENTER
PITTSBURGH ENERGY TECHNOLOGY CENTER
CARBONDALE MINING OPERATIONS CENTER
PITTSBURGH MINING OPERATIONS CENTER

The Deputy Assistant Secretary for Oil, Gas and Shale Technology directs and manages a research and technology program involving all aspects of oil, gas, shale and in situ coal gasification technology including development of technologies for processing of synthetic liquid or gas products.

The line offices are supported by three additional offices. The Office of Plans and Technology Assessment is responsible for long-range strategic planning, environmental policy and guidance, cost estimating guidelines and independent program evaluation. The Office of Advanced Research and Technology develops an integrated Fossil Energy advanced research program and initiates advanced technology concepts. The Office of International and Scientific Programs is responsible for negotiation and coordination of all international Fossil Energy agreements and for foreign technology assessment.

Fossil Energy Technology Centers, Operations Offices, and National Laboratories

The Fossil Energy technology and mining operations centers, the DOE operations offices, and national laboratories play an important role in achieving the DOE goals and objectives in fossil energy research, development and demonstration. This role is currently being expanded through the decentralization of project management to these institutions. Staff at these field facilities is made up of highly skilled scientists, engineers and technicians, many with long histories of accomplishments in production, conversion, and use of fossil fuels. They are relied on for new ideas, information and process development to better utilize our fossil energy resources with greater efficiency and environmental acceptability.

COAL PROGRAM

I would like to turn now to the Coal RD&D program. This program is the cornerstone of our energy development efforts. Coal provides an abundant domestic storehouse of energy for direct use as a fuel in an efficient and environmentally acceptable manner and for processing into substitutes for oil and natural gas.

Coal is the Nation's most plentiful fuel resource, with enough reserves to last several centuries. It offers the greatest potential in the 1980s for relieving or minimizing the current U.S. dependence on imported energy sources. The United States has reserves estimated at 3.2 trillion tons of unmined coal, whereas supplies of oil and natural gas are becoming rapidly depleted. Coal constitutes about 77 percent of U.S. conventional energy reserves, but currently supplies less than 20 percent of energy consumption.

Coal is capable of supplying energy for all demand sectors since it can be burned directly or transformed into liquids, gases or chemical feedstocks. But the full potential of coal cannot be realized until a number of problems are solved. Coal is bulky and therefore is more difficult to transport and burn than liquid and gaseous fuels, the transportation system for increased quantities may be inadequate, and coal burning is a source of pollution. The processes for making liquids and gas from a wide variety of U.S. coals have yet to be fully developed to meet rigorous environmental standards and marketplace competition.

To surmount these problems, DOE's coal resource program focuses on the following major areas:

- Mining R&D
- Coal Liquefaction
- Surface Coal Gasification
- In Situ Coal Gasification
- Advanced Research & Technology Development
- Advanced Environmental Control Technology
- Combustion Systems
- Heat Engines & Heat Recovery
- Fuel Cells
- Magnetohydrodynamics

For these activities, the Administration is requesting $1,046,906,000 for Fiscal Year 1981, the first time that the coal R,D&D budget has topped $1 billion. The following describes briefly the objectives of each of the activities within the program and lists the major ongoing projects.

MINING RESEARCH AND DEVELOPMENT (FY 1980 - $68,850,000; FY 1981 Request - $46,500,000)

The National Energy Plan (NEP-2) states that "coal... should be used in place of oil and gas wherever economically and environmentally feasible." Since coal must be mined before it can be used in either direct combustion or as a synthetic fuels feedstock in the relatively near term, underlying this goal is the need to develop technologies to improve the economics of mine production and maximize resource recovery while protecting the environment and the health and safety of miners.

From 1945 to 1968, the mining industry experienced increasing productivity, but beginning in 1969, the trend took an abrupt downturn in both underground and surface mining. Productivity dropped by 50 and 30 percent respectively, attributed mostly to more stringent safety, health and environmental procedures.

To reverse this trend, a composite effort of several federal agencies working with the mining industry will be needed. In addition to the mining program in DOE, these agencies (Office of Surface Mining Reclamation and Enforcement, Bureau of Mines, and the Mine Safety and Health Administration) have a combined FY 1980 budget of $103 million for mining-related activities.

pages tightly bound

The Mining R&D program in DOE necessarily includes many technological approaches to cover the spectrum of requirements for different equipment, techniques, and applications. Of roughly 6,200 producing mines in the U.S., only 11 of the companies involved can be considered large. Equipment manufacturers are generally unable to find mine operators who are willing to accept the risk of trying new equipment, and many of the equipment manufacturers are too small to afford extensive R&D on their own. Therein lies the basis the Federal role in mining R&D.

Underground Mining

The underground coal mining program is structured to address each of the basic elements of the mining cycle: mine planning and development; production systems; and transport and supporting systems.

Mine planning can have decisive influence on productivity, safety, economics and environmental impacts both during mining and long after mining has ceased. To provide the mining industry with new tools for more effective mine planning, DOE is working to improve existing geophysical analysis, engineering, computer modeling, and other techniques. Attention is also being focused on improving the mine operators' ability to predict the quantity or quality of underground fluids and coalbed methane as a function of mine layout, sequencing of operations and mining method. Research is also being done to develop a computer simulation model that would link mining operations to economics, thereby permitting mine operators to gauge the cost impacts of changing various mining operations.

Mine development encompasses both (1) coal seam access and (2) in-mine development of entries to establish production centers. Because of the enormous investments required to open a mine -- currently $40 or more per annual ton of production -- accessing and developing coalbeds quickly is key to reducing coal production costs. As part of this effort, DOE is developing mechanized shaft-sinking systems to reduce the time and cost associated with current methods and is also currently evaluating the test results of a modified tunnel boring machine, similar to that used in the construction industry, to determine the potential of designing a similar system specifically for coal operations.

The predominant production system used in the U.S. is room-and-pillar mining, a name derived from the pattern of excavated areas interspaced between supporting columns of coal. Productivity from room-and-pillar mining is hampered by the inability of current mining machines to cut coal continuously. In fact, so-called "continuous miners" actually mine during only 25 percent of a shift, the remaining time spent installing roof supporting bolts or positioning extraction equipment. Therefore, the development of a combination miner/bolter — a single machine capable of performing both mining and roof bolting — is a major priority in this effort as are continuous face haulage systems which are necessary for the miner/bolter to realize its full productive capabilities.

Alternatives to the "room-and-pillar" mining technique are also under development in the Mining R&D program. Principal efforts in this area focus on the "longwall" mining method, a technique where one side of a rectangular block of coal is sheared in long successive slices.

Research to improve methods of transporting men, coal, supplies and materials to and from the working face within a mine area makes up the transport and supporting services activity. Automated rail haulage systems and hydraulic transport are being developed in this effort.

Surface Mining

Surface mining activites are organized into: mine planning and development; production systems; and logistics.

With the advent of new mining regulations, mine planning has also taken on increased importance in surface mining. DOE's program is focusing on (1) developing methods for characterizing coal reserves, including the use of aerial and other remote sensing techniques, and (2) development of improved methods and guidelines to facilitate mine design using simulation models.

The major R&D thrusts in surface mining production systems are to develop new equipment and systems to increase production resource recovery and productivity, improve mining methods using existing equipment to increase resource recovery, and modify existing equipment and improve operating and maintenance techniques. Activites involve both area mining which is generally employed in the relatively flat terrain of the Midwest and West, and contour mining which is applicable to the mountainous terrain of Appalachia.

Logistics research and development is intended to ensure that good auxiliary support operations are available to permit a surface mining operation to operate at full capability. Emphasis is on the development of electrical power distribution systems concepts, mine-wide maintenance systems based on on-board diagnostic equipment, training systems, and improved supervisory control systems, including communications, production and environmental monitoring and data reporting.

The Office of Coal Mining has also developed an adjunct program in alternative coal mining technologies as specified in Section 908 P.L. 95-87, the Surface Mining Control and Reclamation Act of 1977. As identified in the initial 1979 program, primary activities in this area are: the mining of unusually thick seams; in-mine underground waste disposal; and health and safety projects associated with alternative mining technologies.

Coal Preparation

Coal preparation is the process by which raw coal containing such impurities as sulfur, ash, and trace elements is cleaned into a salable product. Through various coal cleaning operations, increasing amounts of coal are being prepared annually at preparation plants at most modern mining operations.

One factor contributing to this increase in coal cleaning is the expanded use of continuous mining techniques, which introduce larger amounts of impurities into the raw coal feed. Another is the Clean Air Act of 1977 which limits sulfur content.

DOE's R&D program involves both physical coal preparation, which separates coal and impurities by taking advantage of their specific gravity differences and chemical cleaning, which produces a product whose physical and chemical properties have been modified from those of the feed. All commercial coal cleaning techniques today rely on physical preparation.

Key aspects of this program involve characterizing the coal by gaining a better understanding of the quanity and quality of coal contained in the waste piles of coal cleaning plants, research into the geochemistry of trace elements in coals of specific geological regions, and studies of the microstructure of coal.

Physical beneficiation techniques under study involve high-gradient magnetic separation and dense-medium cycloning to separate the fine particles of coal from those of ash and pyrite.

Chemical preparation techniques include oxydesulfurization, which oxidizes the organic sulfur impurities so they can be separated from the coal; low temperature chlorinolysis being developed jointly with NASA's Jet Propulsion Laboratory; and several others.

DOE has also successfully demonstrated a new process for drying and compressing lignite into more economical and easily transportable pellets. Commercial demonstration of this process, called "Lignipel", will begin in FY 1981.

Major research areas/projects are shown in Table 1.

TABLE 1

MINING RESEARCH AND DEVELOPMENT

Research Area/Major Projects	FY 1981 Request
UNDERGROUND COAL MINING	$26,000,000
o Mine planning and development	
o Development of Improved mining equipment and systems	
o Novel mine systems for thick, multiple and steeply pitching seams	
o Improved transportation systems for men, supplies, and coal	
SURFACE COAL MINING	$ 8,000,000
o Area mining systems	
o Contour mining systems	
o Reclamation practices to minimize environmental impact	
COAL PREPARATION AND ANALYSIS	$11,000,000
o Physical coal preparation	
o Chemical coal cleaning	
o Improved ancillary unit operations	

The reduction in FY 1981 funding from FY 1980 reflects a decision to emphasize more basic R&D to solve fundamental mining problems, to phase out marginal programs and to stretch out certain elements of this program until a review of project priorities and commitments in the context of needed Federal involvement can be evaluated and a determination made of future program direction.

Coal preparation activities are also included for funding from the revenues expected from the proposed windfall profits tax (see page 30).

LIQUEFACTION (FY 1980 - $250,306,000; FY 1981 Request - $523,900,000)

The development of commercial coal liquefaction will provide a route, within environmental guidelines, to increase domestic production of clean fossil fuels and feedstocks. Synthetic fuels derived from coal liquefaction processes can replace petroleum-refined products most effectively in two distinct markets. One market uses low-ash, low-sulfur boiler fuels suitable for clean generation of electric power and industrial steam. The other uses high-grade fuels such as jet and diesel fuel, gasoline, heating oil and chemical feedstocks.

The initial commercial coal liquefaction facilities for western coals will probably be based on western coals and indirect liquefaction technology, where coal is first gasified and the gases are recombined into a variety of liquid products. Such techniques, which include the Fischer-Tropsch process currently in commercial use outside the U.S. or a coal-to-methanol/methanol-to-gasoline process route, are prime candidates today for funding by the Energy Security Corporation. However, supporting R&D is still needed to enhance their commercial prospects in the U.S. Specific areas where such support is most needed are equipment for environmental control and for product slate upgrading, and instrumentation for process monitoring and control. Additional work on indirect coal liquefaction is proposed for funding from the revenue generated from the President's windfall profits tax (see page 30).

There are also several coal liquefaction technologies currently under development for both eastern and western coals that can be ready for commercial deployment within the next few years. These technologies include processes for indirect liquefaction through the gasification of western coals and the more efficient direct liquefaction processes, where coal is converted directly into a liquid without the gasification step. Commercial facilities based on these more advanced technologies would offer improved economic and environmental performance and could be operating commercially in the late 1980s or early 1990s.

Therefore, the Liquefaction Activity is planned to:

- Demonstrate the technical capability to produce commercially clean liquid and solid fuels from coal by at least four direct liquefaction processes (Solvent-Refined-Coal I, Solvent-Refined-Coal II, H-Coal, and Exxon Donor Solvent) by the late 1980s;
- Develop improved indirect liquefaction processes to produce liquid fuels from synthesis gas made from coal by the late 1980s; and
- Promote the development of more advanced third-generation coal liquefaction processes which can be demonstrated to be commercially viable in the 1990-2000 time frame.

The general strategy of the liquefaction program is to support several liquefaction processes in parallel from laboratory scale through process development unit. The most promising candidates are selected to advance to the pilot plant stage, and only those processes identified as meeting commercial market needs are considered for major scale-up.

This approach is based on several considerations. First, market requirements for a wide range of fuels produced from a variety of coals, coupled with the need for a large number of plants to produce significant quantities, may require scaling up several liquefaction processes. This variety of processes is evident in today's crude-oil-based liquid fuels industry. A future national synthetic fuels industry, which will replace a large share of this fuel market, cannot rely on any single process configuration. Second, the processes under development provide complementary support to each other in many ways. Third, all processes under development require supporting research to improve overall operability, increase efficiency, and reduce costs.

We can point to significant progress in this program:

- In the Solvent-Refined-Coal program, five years of test runs at 6 and 50 ton-per-day pilot plants have given us the technical confidence to proceed toward the construction of two 6000 ton-per-day demonstration modules, each testing a variation of the technology. Last year, our industrial partners completed the preliminary designs (Phase 0) and are currently well into the detailed design phase. In FY 1981, we will begin construction of these facilities and have budgeted a total of $365 million ($175 million for SRC-I, $190 million for SRC-II) for this activity;

- We dedicated the 250-ton per day Exxon Donor Solvent pilot plant earlier this month, signifying the completion of two years of construction. First coal input is expected to begin by the end of April and we will be operating the facility and continuing laboratory and engineering research support for the rest of this year and throughout FY 1981;

- We are nearing completion of the 600-ton per day Ashland Oil H-Coal pilot and likewise expect to begin operations this year and continue the testing program into FY 1981 at both the pilot plant and the 3 ton-per-day process development unit.

Although these direct liquefaction technologies differ in many important aspects, their successful commercialization is largely dependent on the development of a common technology base. Therefore, demonstration plants are not planned for the H-Coal and Exxon Donor Solvent processes; rather it is considered that these two processes will be able to proceed directly from the large pilot plants to the design of pioneer size commercial facilities with the safety, environmental, licensing, and performance assurance and management experience gleaned from the Solvent-Refined-Coal demonstration.

Supporting research and development activities provide critical backup to these and other specific processes with improvements in the technology which in turn can provide significant improvments in process economics. Two major problem areas common to most liquefaction processes are under study: utilization of bottoms containing ash and unreacted coal for hydrogen production; and durability of auxiliary equipment. Significant effort is devoted to engineering studies and analyses which are required to guide and evaluate process development work.

A major effort is also being directed towards environmental concerns associated with coal liquefaction processes. Of particular concern is the presence of potentially toxic and carcinogenic organic compounds in coal liquid products and residues. The presence of potentially toxic trace minerals in the products and byproducts is also under investigation. The environmental impact of coal liquefaction processes is being investigated and studies are being conducted at the pilot plant level to develop adequate health and safety procedures for worker protection.

Major activities funded under this heading are shown in Table 2.

TABLE 2

LIQUEFACTION

Research Area/Major Projects	FY 1981 Status	FY 1981 Request
H-Coal Pilot Plant Catlettsburg, KY	Operational	$ 57,000,000
Exxon Donor Solvent Pilot Plant Baytown, TX	Operational	$ 32,000,000
SRC Pilot Plant (50 tpd) Ft. Lewis, WA	Operational	$ 28,000,000
SRC Demonstration Plant Newman, KY (SRC-I)	Phase I Detailed Design; Start of Construction	$175,000,000 (construction) $ 5,000,000 (operating exp.)
SRC Demonstration Plant Morgantown, WV (SRC-II)	Phase I Detailed Design; Start of Construction	$190,000,000 (construction) 5,000,000 (operating)
Third Generation Processes	Operational	$ 19,200,000
Environmental Studies & Other Support	Ongoing	$ 12,000,000

SURFACE GASIFICATION (FY 1980 - $115,850,000; FY 1981 Request - $138,500,000)

The overall objective of the Surface Gasification Activity is to develop and demonstrate, in cooperation with industry, advanced environmentally acceptable technology needed to gasify coal.

Successful development of this technology will enable the United States to use its large deposits of coal to produce a wide variety of energy products and chemical feedstocks, not only as gases but because gasification is the critical first step of indirect liquefaction, useful liquids as well. Applications of coal gasification are shown below:

Coal Liquefaction
- Indirect (synthesis gas)
- Direct (synthesis gas to hydrogen)

Synthetic Pipeline Gas
- High Btu Gas (Methane)

Industrial and Utility Fuel Gas
- Medium Btu Gas
- Low Btu Gas

Combined Cycle Systems
- Fuel Cells -- synthesis gas/hydrogen
- Turbines -- low or medium Btu gas

Chemical Feedstocks
- Synthesis Gas

Technical confidence in today's commercially available gasifiers is highest when applied to western, non-caking coals. Therefore, in considering the various applications and the limitations of currently available gasifiers, it is apparent that the greatest need is for a gasifier capable of accepting a wider range of U.S. coals, including the caking coals of the Midwest and Applachian regions.

In the high-Btu gasification program, the Government-supported activity includes four major second-generation projects for manufacturing pipeline quality substitute natural gas (SNG) from coal and the evaluation of peat as a potential feedstock. Two of the processes, BiGas and Hygas, are currently being tested at pilot plant scales. The other two, British Gas/Lurgi slagging gasifier and the COGAS process, are currently being used in the designs of two demonstration plants. Later this spring, DOE anticipates selecting one of the two demonstration projects to proceed toward actual construction slated to begin in FY 1981.

In the medium-Btu gasification area, a decision has been made to continue design of a demonstration plant proposed by Memphis Light,Gas and Water Division, contingent upon the successful negotiation of cost-sharing terms, a finding by the Secretary of the suitability of the proposed site, and the completion of an environmental impact statement. Fifty million dollars in deferred prior year funds will carry the demonstration project through FY 1980 and into FY 1981. Should construction be authorized, additional funds may be required in FY 1981 to maintain the schedule.

DOE has also decided to fund the initial design of a commercial scale facility proposed by W.R. Grace to process coal first into medium-Btu gas which would then be converted into methanol and ultimately to gasoline. The Fossil Energy office is currently developing an appropriate approach for providing the required funding including the preparation of any necessary Congressional submissions.

In the low-Btu gasification activity, promising new concepts for improved gasification techniques are being developed at the process development unit and pilot plant levels. These include fixed-bed, entrained-bed, fluidized-bed and molten salt systems. In addition, the Department is preparing to reopen negotiations for contracts to design a low-Btu gasification demonstration plant that would feed an adjacent utility boiler.

More advanced gasification techniques, so-called "third generation" processes, are also being developed. Although longer term and of greater technical risk, these concepts offer the possibility of substantially improved overall process economics, especially for the production of pipeline quality gas. For pipeline applications, catalytic coal gasification, hydrogasification, and high mass flux gasifiers are under development. In a similar manner, a molten salt gasification process is being developed for medium-Btu or synthesis gas applications.

Environmental control is an integral part of the Surface Gasification Activity and is accorded a high priority with each development project. Early identification and characterization of potential environmental contaminants is necessary to minimize ultimate impacts.

A listing of major development efforts is shown in Table 3.

TABLE 3

SURFACE GASIFICATION

Research Area/Major Projects	FY 1981 Status	FY 1981 Request
High Btu Demonstration Plant site undetermined	Detailed design and Construction	$55,000,000 (construction) $ 1,000,000 (operating expenses)
Medium Btu Demonstration Plant	Detailed design; possibly construction	see text
BiGas Pilot Plant Homer City, PA	Operational	$10,000,000
Peat Gasification	Study and possible modification of Hygas pilot plant	$13,000,000
Fixed Bed Gasification Morgantown, WV; Grand Forks,ND	Operational	$ 7,000,000
Fluidized Bed Gasification Monroeville, PA (2), Trenton, NJ	Operational	$ 9,000,000
Entrained Bed Gasification Windsor, CN	Operational	$ 3,000,000
Third Generation Processes	Operational	$30,000,000
Gasifiers in Industry (4) PA (2), MN, KY	Operational or Construction	0
Technical Support		$10,000,000

IN-SITU COAL GASIFICATION (FY 1980 - $10,000,000; FY 1981 Request-$10,000,000)

The objective of the In-Situ Coal Gasification activity is to develop commercially viable underground coal conversion processes for extracting energy from coal resources which might otherwise be considered marginally attractive. Approximately 93 percent of the Nation's vast coal resource is not technically or economically recoverable by conventional underground or surface mining. Converting coal underground to useful fuels could increase the recoverable portion by almost four-fold. As a complement to mining plus surface-based synthetic fuel production, the development of underground conversion processes could significantly expand the economic extraction of energy from coal in environmentally acceptable ways, and may provide a viable domestic source of competitively priced transportation fuels.

Through joint participation by government and industry, the technology will be developed, proven on a large scale, and transferred to the private sector. Data will also be provided to predict the economics of commercial operations. The near-term goal is to develop at least one commercial underground process by 1985 to 1987 and assure transfer of the technology to the industrial sector. The mid-term goal is to develop advanced concepts, i.e., increased resource recovery, reduced water usage, and reduced dependence on underground characteristics.

The four major underground coal gasification process options being developed address the wide range of chemical and physical properties of U.S. coal seams and surrounding geology:

- A Low-Btu Gasification project is concentrating on gasifying subbituminous coal using air after linking pairs of wells with reverse combustion;
- A Medium-Btu Gasification project is concentrating on gasifying bituminous or subbituminous coal with oxygen and steam injection after linking pairs of wells using directionally drilled holes;
- A Steeply Dipping Bed project is concentrating on gasifying coal seams which dip more than 35° and are not commercially exploitable with conventional mining technology;
- A project is concentrating on gasifying swelling bituminous coals using the best available technology.

The Environmental Support and Supporting Research projects contribute to all four major projects by determining the true impact of environmental problems associated with in situ coal gasification and methods for their control and by developing new technology with general applications. One example is the development of inverted thermocouples to monitor the growth of the underground cavity as gasification progresses.

An additional $10,000,000 will be requested from the expected revenues of the proposed windfall profits tax. These funds would permit continuation of a five-to-six year program to demonstrate the technology at near commercial scale (see page 30)

Major areas of research are shown in Table 4.

TABLE 4

IN SITU GASIFICATION

Research Area/Major Project	FY 1981 Status	FY 1981 Request
Western Low-Btu Gas (Hanna, WY)/Steeply Dipping Beds (Rawlins, WY)	Post-burn evaluation/ Complete demonstration of larger-scale feasibility test	$ 6,500,000
Western Med-Btu Gas Hoe Creek, WY	Evaluation of Hoe Creek III field test	$ 2,700,000
Supporting Research	Ongoing	$ 200,000
Environmental Support	Ongoing	$ 500,000

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT (FY 1980 - $56,150,000; FY 1981 Request - $64,461,000)

Advanced Research and Technology Development (AR&TD) covers a diverse group of activities ranging from applied research to research and development supporting activities. Major categories of activity include:

- o Processes -- where the objective is to develop basic chemical and engineering knowledge to speed development of synthetic fuel technologies; determine the technical feasibility of new process concepts; and conduct supporting research in areas such as catalyst research to complement or improve on-going process development;
- o Direct Utilization -- where emphasis is in the areas of fundamental coal and synfuel combustion research, combustion system control technologies; and generic heat exchanger technology;
- o Materials and Components -- where elements include failure analysis of pilot plant materials; studies of erosion, corrosion, abrasion, fatigue and other forms of deterioration; selection and development of economical and durable materials; operation materials test facilities; and investigation of extra-strong and weldable steels for thick-walled pressure vessels.

- Program Development and Integration -- including budget and administration, engineering analysis, environmental activities, and planning and policy.
- University Research -- with a focus on a national and regional program of university research on coal conversion and utilization.

Approximately 50 percent of AR&TD projects are conducted by industry, 25 percent by the Energy Technology Centers, National Laboratories, and other Govern ment agencies, and 25 percent by universities. Major areas of research and/or support are shown in Table 5:

TABLE 5

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Research/Area/Major Projects	FY 1981 Request
Processes	$20,400,000
Direct Utilization	$11,000,000
Materials and Components	$ 9,000,000
Program Development and Coordination	$ 7,861,000
University Coal Research	$ 5,000,000
General Plant Projects and Construction at Fossil Energy Technology Centers	$10,700,000

ADVANCED ENVIRONMENTAL CONTROL TECHNOLOGY (FY 1980 - $38,250,000; FY 1981 - $42,500,000)

If coal is truly to play an increasingly important role in decreasing the Nation's dependence on imported oil, technology must be developed to minimize the environmental impacts of coal combustion. These environmental concerns today pose the greatest constraint on increasing direct coal use.

Sulfur, nitrogen, alkali and halogen compounds, and volatile trace metals are found in varying amounts in coal and are released by gasification and combustion processes. These substances, besides having harmful effects on health and the environment, can also degrade the performance of energy-producing systems such as turbines and fuel cells.

Therefore, the Advanced Environmental Control Technology program is developing engineering approaches that can remove pollutants or undesirable components at the back end of the system (flue gas cleanup), during the combustion process, or from the process stream prior to utilization (gas stream cleanup) and management of associated fossil energy wastes.

This program is a new effort in DOE which began in FY 1979, although certain related efforts had been conducted previously in other Fossil Energy programs. In conjunction with such organizations as EPA, EPRI, TVA, and others, DOE will be involved in FY 1981 in activities such as:

- a full-scale demonstration of a lime/limestone scrubber using chemical additives to enhance performance (in cooperation with EPA);
- characterization of two operational utility lime/limestone scrubbers (coordinated with EPRI's efforts);
- support of TVA's 10-megawatt experimental scrubbers at the Shawnee power station;
- continuation of major dry-scrubbing efforts for both low- and high-sulfur coal applications;
- selection of advanced flue gas desulfurization system for full-scale, cost-shared utility demonstration;
- monitoring of full scale utility baghouse applications using western coals;
- pilot-scale evaluations of advanced combined NOx/SOx scrubber processes;
- small-scale testing of hot-gas cleanup equipment for pressurized fluidized bed coal combustors;
- evaluation of gas cleanup requirements for the molten carbonate fuel cell; and
- completion of a pilot effort to characterize fossil energy waste streams and assessements of the impact of the Resource Conservation and Recovery Act.

Major areas of research and/or support are shown in Table 6.

TABLE 6

ADVANCED ENVIRONMENTAL CONTROL TECHNOLOGY

Research Area/Major Projects	FY 1981 Request
Flue Gas Cleanup	$21,000,000
Gas Stream Cleanup	$13,000,000
Cleanup Base Technology	$ 8,000,000

HEAT ENGINES AND HEAT RECOVERY (FY 1980 - $50,500,000; FY 1981 Request - $43,400,000)

The Heat Engines and Heat Recovery Activity focuses on three major areas where improved coal derived fuel technology will permit savings in critical fuels consumption:

Central Power Systems	— new technology applied to base and intermediate load central station utility power plants*;
Dispersed Power Systems	— new technology applied to small municipal utility & cogeneration plants**;
Heat Recovery Component Technology	— new technology applied to utility/residential commercial, or industrial applications.

Today's utilities consume almost three and a half times as much fuel energy as they produce in electrical energy, with the unused portion usually rejected as waste heat. Likewise, a substantial portion of the energy consumed by the Nation's residences, businesses and industries is also rejected without extracting any useful work. The opportunities for improving these wasteful energy patterns provides the impetus for the Heat Engines and Heat Recovery program.

In the central power systems activity, R&D is carried out to increase the efficiency of utility power generation. For instance, the integrated high temperature turbine/gasification combined-cycle system offers substantial potential for improved economics, higher efficiency and lower emission levels, particularly when compared to today's conventional powerplants with scrubbers.

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* Previously called "Integrated Coal Conversion and Utilization Systems"

** Previously called "Advanced Cogeneration Systems"

The R&D efforts in the Dispersed Power Systems activity focus on smaller systems, typically industrial or small utility size stationary heat engine systems. In these applications, simultaneously producing both electricity and heat, a concept called "cogeneration", can be one of the most efficient means of improving fuel use.

Studies have shown that the best coal-derived liquid fuel cogeneration options are stationary diesels for residential/commercial total energy systems and stationary gas turbines for industrial cogeneration. The heat engine systems offering the greatest fuel flexibility and economic attractiveness for solid coal use in cogeneration are those based upon the atmospheric fluidzed bed coal combustor. Expanding the atmospheric fluidized bed combustor option to include gas turbines (both open and closed cycle) as well as steam turbine systems can more than double the market development for advanced coal cogeneration.

Heat recovery component technology can offset fuel now burned to produce work by tapping previously rejected heat and converting it to useful purposes. Technology developed in this program would have applications in utilities, industries, and residential/commerical installations. Residual energy applications of the heat currently being rejected by the coal-fueled DOE-owned gaseous diffusion plants and nuclear weapons processing facility have been determined to be the most efficient and expedient way for the government to demonstrate these technologies to the private sector.

Major projects are shown in Table 7.

TABLE 7

HEAT ENGINES & HEAT RECOVERY

Research Area/Major Projects	FY 1981 Status	FY 1981 Budge
Central Power Systems		
-- Closed Cycle Coal Fired Primary Heater	Continue Phased Technology Devel.	$ 2,400,000
-- Open Cycle Systems (includes High Temp. Turbine Technology)	Complete Phase II Testing;Initiate Phase III, Verification Testing	$19,800,000
Dispersed Power Systems		
-- Directly fired heat cycles (low NOx combustors and ceramic coatings)	Phase II Full Scale Development	$10,600,000
-- Externally fired heat cycles	Detailed design evaluation of open cycle gas turbine; complete high efficiency small steam turbine test; design of stationary Stirling engine;	$ 3,200,000
-- Prototype Systems Assessment	Site specific industrial cogeneration designs	$ 3,100,000
Heat Recovery Component Tech.		
-- Low grade heat recovery from Federal facilities	Initiate	$ 4,300,000
-- High grade heat recovery	Complete 6 field tests	0

Principal causes for the FY 1981 budget reduction are a stretch out of the high temperature turbine technology program from the originally estimated six years to the present schedule for completion in about 10 years, and the use of $4.5 million carried over from FY 1980 Congressional appropriations for low-grade heat recovery. In 1980 the high-grade heat recovery program will be completed and no further funds will be required.

COMBUSTION SYSTEMS (FY 1980 - $50,850,000; FY 1981 Request - $68,500,000)

The primary objectives of the Combustion Systems activity are to:

- o Develop fluidized-bed combustion systems capable of burning high-sulfur and other coals of all ranks and qualities while removing major sulfur pollutants in the boiler before they can escape up the stack;

- Develop technology to substitute coal for a substantial portion of oil in combustors capable of firing coal-oil or other coal-based mixtures.

The initial commercial target of fluidized bed combustion technology is industrial application of units that operate at atmospheric pressure, typically generating less than 250,000 pounds of saturated steam per hour.

The program to develop systems for this market has resulted in several significant accomplishments during the last year. An atmospheric fluidized bed boiler began providing steam to the Washington, D.C. campus of Georgetown University in July 1979. In the following five months, the 100,000 lb/hr boiler accumulated over 1000 hours of run time. Stringent District of Columbia environmental standards were met for sulfur dioxide, NOx, and particulates.

Construction of the 50,000 lb/hr atmospheric fluidized bed boiler at the Great Lakes Naval Training Center, near Chicago, started in early 1979 and will be completed by the end of fiscal 1980. Construction of two atmospheric fluidized bed boilers designed to burn anthracite culm (waste material from coal cleaning operations) will begin in FY 1980. One unit, capable of generating 20,000 lb/hr steam is located at Shamokin, PA; the second, consiisting of a 100,000 lb/hr boiler, is part of the Cityof Wilkes-Barre, PA, central heating and air conditioning system. A third such boiler design is awaiting site selection.

For utility applications, the Tennessee Valley Authority (TVA) has undertaken a major program to demonstrate atmospheric fluidized bed technology at a size suitable for baseload power generation. DOE's Fossil Energy program will support this effort by providing technical data from current and planned projects that benefit both industrial and utility applications.

In view of TVA's involvement in developing atmospheric fluidized bed units for utility power generation, DOE will focus its efforts in utility applications on the pressurized concept.

Pressurizing the fluidized bed combustor permits higher efficiency combined cycle applications as well as increased sulfur retention and therefore better environmental performance. Following significant successes in turbine materials tests at Curtiss-Wright's Wood-Ridge, NJ facility and at Leatherhead, England, DOE is preparing to begin construction of a 13-MWe pressurized fluidized bed/ combined cycle power plant in FY 1980 at the Curtiss-Wright's Wood-Ridge, NJ, site. Testing is slated to begin in FY 1982.

Engineering analysis will also be started in 1980 to determine whether early system configurations of pressurized fluidized bed and combined cycle gasification systems can be demonstrated at commercial scale by the mid 1980s.

The coal-oil mixture program represents the largest budget increase in the combustion program, primarily since the technology is considered to be one of the nearest term ways of substantially reducing utility and industrial oil consumption. The first long-term test burn of coal-oil mixtures in a utility boiler (originally designed to burn coal) began in 1979 at New England Power Co.'s Salem, MA power plant, and testing of coal oil mixtures in a blast furnace is about to begin at the Interlake, Inc. steel plant in Chicago.

In addition to these two demonstrations, DOE is asking prospective contractors to submit proposals for additional demonstrations of retrofitting for coal-oil mixtures in:

- an existing utility boiler, originally designed to fire oil, 100 MWe minimum capacity;
- an existing utility boiler, designed to fire oil with intended conversion to coal, 100 MWe minimum capacity;
- existing industrial boiler designed to fire oil, greater than 100 million Btu/hr energy input;
- new industrial boiler designed to fire coal-oil mixtures as the primary fuel, greater than 100 million Btu/hr energy input.

Additionally, coal-oil mixture fuel for these demonstrations will be purchased under contract by the selected offeror who is expected to construct, if necessary, and operate a preparation plant at his own expense. To stimulate such ventures, DOE will reimburse a portion of the price of the fuel if circumstances warrant.

These demonstrations, along with continued testing on smaller units at DOE's Pittsburgh Energy Technology Center, should provide the information needed by the Department's regulatory arm to enforce the provisions of the Fuel Use Act as they apply to coal-oil mixtures. If industry's confidence can be built in this fuel, significant proportions of oil could be saved in both the utility and industrial markets beginning in the early part of this decade. In the utility sector alone, coal-oil mixtures could potentially displace one-third of the approximately 1.8 million barrels of fuel oil now used daily. That amounts to some 600,000 barrels per day — or to place that in perspective, slightly less than we once imported from Iran. Even if we can achieve only 30 to 60 percent of the potential market, coal-oil mixtures can play a significant near-term role in removing our dependence on foreign oil.

TABLE 8

COMBUSTION SYSTEMS

Research Area/Major Projects	FY 1981 Status	FY 1981 Request
Atmospheric Fluidized Bed		
— AFB Boiler, 30 MWe Rivesville, WV	Complete Operations	$ 3,100,000
— AFB Industrial Operations Various locations	Operational	$ 5,200,000
— AFB Component Test & Integration Unit Morgantown, WV	Installation of Equipment	$10,000,000
— AFB Anthracite Applications, PA (2)	Start-up	$ 3,500,000
— AFB Support	Ongoing	$ 1,000,000
Pressurized Fluidized Bed		
— PFB Combined Cycle Pilot Plant Wood-Ridge, CN	Complete Construction	$13,200,000
— PFB Support/IEA Grimethorpe, Eng.	Complete Construction	$ 8,200,000
Alternative Fuel Utilization		
— Coal-Oil Mixtures	Support Program Opportunity Notice; Continue R&D	$22,000,000
Advanced Combustion Technology		
— Engine combustion tech. (managed by DOE's Office of Conservation & Solar)	Ongoing	$ 2,000,000

FUEL CELLS (FY 1980 - $26,500,000; FY 1981 Request - $25,000,000)

By electrochemically converting hydrocarbon fuels into electricity, fuel cells offer the potential of high efficiencies well beyond combustion based technologies with little to no environmental impact. The high efficiency of fuel cell power plants, and the ability to operate on a wide range of hydrocarbons will provide for use of higher priced coal derived and other unconventional fuels with the least possible inflationary impact on the economy.

This technology has a wide range of applications including utility and on-site systems for industrial, commercial and residential applications. Fuel cell power plants can be factory built and then located close to the point of electricity demand, thereby avoiding energy losses presently associated with power transmission and distribution. Waste heat from a fuel cell can be channeled into additional applications, such as space heating. The modular construction provides a size flexibility ranging from kilowatt to megawatt capacities.

The objective of DOE's Fossil Energy Fuel Cells activity is to establish the commercial feasibility of fuel cell power plants for electric utility applications, industrial cogeneration, and onsite total energy systems in the near term, and to develop advanced, higher efficiency, economically competitive fuel cell technologies for all end-use applications in the longer term.

The Fuel Cell program is assisting, over the next three to seven years, the development of a fuel cell industry with its associated significant national benefits. Activities are divided into four main categories:

- 4.8 MW Electric Utility Power Plant Demonstration: On a utility grid, test the operational feasibility and full-scale system integration of early design (1976) electric utility fuel cells; Currently being installed on Manhattan Island; testing to begin in early 1981;
- Phosphoric Acid Systems Development: Develop fuel cell systems for on-site, cogeneration applications and provide technology to lower cost and increase reliability of phosphoric acid fuel cell systems for both electic utility service and on-site cogeneration applications. Program focuses on developing components and system configurations amenable to mass production manufacturing methods, and use of coal derived and unconventional hydrocarbon fuels.
- Molten Carbonate Systems Development: Advance the state of the art of molten carbonate fuel cells to achieve the earliest possible commercialization of coal-fueled power plants in electric utility baseload and industrial cogeneration applications. Development will continue at the cell and small stack level until it can be determined that operations at commercial scales are viable;
- Fuel Cell Advanced Systems: Support emerging systems with a sufficient technology base, examine advanced fuel cell systems such as solid oxide fuel cells and thermionics, and broaden the spectrum of acceptable fuels.

Major areas of research are shown in Table 9.

TABLE 9

FUEL CELLS

Research Area/Major Projects	FY 1981 Status	FY 1981 Request
4.8 MW Utility Demonstration	Testing Operations	0
Phosphoric Acid Systems Development	Continue program to design, fabricate, and test full size integral cell stacks for utility power plant	$11,000,000
Molten Carbonate Systems Development	Exploratory development	$11,000,000
Advanced Concepts	Ongoing R&D	$ 3,000,000

MAGNETOHYDRODYNAMICS (FY 1980 - $75,000,000; FY 1981 Request - $72,000,000)

As part of the national drive to use coal more efficiently as a replacement for oil in electrical generation, DOE's MHD development offers the potential of using coal at less cost and environmental intrusion, and at higher efficiencies than any other directly-fired coal system.

MHD systems generate electricity directly from the movement of hot, electrically conductive combustion gases through an intense magnetic field. The systems can be coupled to a steam electric generator so that the hot exhaust can be used to power a conventional steam-cycle generating system, thereby improving the overall efficiency of a baseload plant. Environmentally, MHD systems remove sulfur as an inherent part of the process, thus reducing the need for extensive clean-up equipment such as scrubbers. Recent experiments further indicate that NOx formation can be effectively suppressed. Another environmental advantage is that, because at least 50 percent more power is produced from a given quantity of coal, less heat is wasted, less cooling water is required, and less coal must be mined, transported, and processed.

The immediate objective of the MHD program is to facilitate the commercial application of the advanced coal-burning system through the design, construction and operation of a commercial prototype MHD power plant, designated the Engineering Test Facility. Operation of this plant would demonstrate the commercial readiness of MHD as a future source of low cost, coal-fired central-station electric power without need of a larger commercial demonstration plant.

The program uses numerous facilities at various locations in 15 states. Two major government test facilities are also being completed to accomodate key development and integrated engineering tests at larger scales than are available elsewhere in the U.S.

One of the facilities is the Component Development and Integration Facility, currently nearing completion in Butte, Montana. This facility will be the principal facility within the MHD program for continuous testing of engineering scale power trains. Initial testing will be at the 50 MW (thermal) level, with later modifications.

The second facility is the Coal Fired Flow Facility located adjacent to the University of Tennessee Space Institute near Tullahoma, Tennessee. It will be capable of continous operation at a nominal input of 20 MW (thermal) and short duration testing at higher levels. Construction is presently over 95 percent complete, and the facility will be activated in FY 1980.

While the prime activity in the MHD program is on the open-cycle system, DOE is also working on a closed-cycle concept, where a noble gas is cycled through the MHD flow-train and steam system, then recompressed and recirculated. Under a recently-signed agreement with the Netherlands, the U.S. will design and fabricate a channel to be tested in a 5 MW (thermal) facility at the Technical University of Eindhoven.

Major MHD activities are shown in Table 10.

TABLE 10

MAGNETOHYDRODYNAMICS

Research Area/Major Projects	FY 1981 Request
CDIF Project, Butte, Montana	$17,200,000
Engineering Development Technology	$31,800,000
Systems Engineering	$ 8,700,000
Engineering Test Facility	$ 400,000
Supporting Research	$11,400,000
Closed Cycle Systems	$ 2,000,000

WINDFALL TAX REVENUES (FY 1981 Request - $50,000,000)

Speaking to the Nation on April 5, 1979, the President proposed using the revenues generated by the Administration's windfall profits tax to provide increased funding for coal research, development and demonstration. Major objectives of the technology development work to be conducted using funds are to:

- o develop improved technology for converting coal to synthetic liquid and gaseous fuels; and
- o develop new coal mining and coal preparation techniques and systems to handle the projected increase in the demand for coal more efficiently.

DOE has identified four major areas which would be supported in FY 1981 if funds become available from this source:

- o Coal preparation and analysis --improve processes for sulfur and ash removal to ensure that synfuel feedstock coal quality requirements can be met;
- o Coal liquids refining -- begin a 7-year program to prepare and evaluate pilot scale quantities of finished fuels derived from coal and oil shale.
- o Indirect liquefaction -- combination of bench and pilot scale efforts to improve methods of converting synthesis gas to liquid hydrocarbons. Includes start of construction of 100 bbl/day pilot plant for converting methanol to gasoline via the Mobil M-Gasoline process; revamping of a 35 bbl/day syngas conversion plant; and evaluation of SASOL data.
- o In Situ Gasification -- begin a 5-year cost-shared program leading to a pilot scale demonstration of underground gasification of coal.

Funding for these categories is shown in Table 11.

TABLE 11

WINDFALL PROFITS TAX REVENUES

Research Area/Major Projects	FY 1981 Request
Coal Preparation and Analysis	$ 7,000,000
Coal Liquids Refining	$ 5,000,000
Indirect Liquefaction	$28,000,000
In Situ Gasification	$10,000,000

PETROLEUM PROGRAM

Petroleum will continue to be one of the Nation's major energy sources for many years with domestic petroleum demand expected to be about 18 million barrels per day in 1980.

The President has set a U.S. ceiling of 8.2 million barrels per day for oil imports and has issued a challenge to reduce oil imports to 7 million barrels per day by 1990. Achieving these goals will be a major challenge in that the U.S. faces a declining base of its own oil reserves. U.S. proved reserves have declined from 39 billion barrels in 1971 to below 28 billion barrels in 1979. The severity of the decline in reserves has been masked by the steady increase of production from the Alaskan North Slope; however, the Alaska pipeline and the Prudhoe Bay Field are now near peak capacity at 1.6 million barrels per day. To reach the 1990 import reduction goal, the U.S. will need to replace three million barrels per day of domestic oil production and over one million barrels per day of oil imports.

The goal of the Petroleum R&D program is to increase the production of oil from domestic sources by developing new and improved techniques of recovering oil from existing and potential oil reservoirs, from both on and offshore areas, as well as non-conventional sources such as oil shale and tar sands.

The strategy for implementing the program is to encourage and support industry efforts by:

- o Determining critical technology needs;
- o Identifying and setting priorities for R&D efforts and determining the appropriate government role based on the above needs;

- o Establishing and implementing cost-shared development and demonstration projects where appropriate;
- o Maintaining an aggressive research program; and
- o Providing for documentation and dissemination of data obtained from the DOE-sponsored activities.

The FY 1981 request in this program area is $63,758,000. The decrease from FY 1980 reflects lower requirements for the Enhanced Oil Recovery activities due to the implementation of new regulations aimed at encouraging commercialization of near-term technologies.

ENHANCED OIL RECOVERY (FY 1980 - $23,100,000; FY 1981 Request - $19,400,000)

Currently in the U.S., there are over 300 billion barrels of oil known to exist that cannot be recovered by conventional techniques. The research effort in the Enhanced Oil Recovery program is designed to assist in the development of the technology to recover a significant proportion of this oil, perhaps as much as 52 billion additional barrels

The most mature enhanced oil recovery technologies are thermal (steam) processes which are applicable to heavy oils found in high permeability, thick reservoirs at shallow depths. Technology is currently under development to enable recovery at greater depths, from the more difficult reservoire and to improve recovery efficiency. This technology can be brought to commercial readiness within a few years. Not only is one-third of the oil remaining in the U.S. heavy oil, but vast quantities of heavy oil resources exist in the Western Hemisphere in Canada, Mexico and Venezuela.

The other two thirds of the remaining oil in the U.S. is light oil. Light oils are more easily refined than heavy oils, are compatible with our existing refinery base and produce a product slate which emphasizes transportation fuels. The most mature technologies for light oil recovery are polymer flooding and carbon dioxide gas flooding, yet both are limited by technical factors which constrain their effectiveness and lead to low incremental improvements over recovery by waterflooding.

Examination of 1978 production data indicates that industry is only conducting pilot tests of the chemical approach, while carbon dioxide injection is being applied in commercial practice in only one field and in a secondary, not a true tertiary application. Industry has indicated plans, however, to undertake several carbon dioxide injection projects.

Producing bitumen from tar sands presents the most challenging problems. Until recently, limited public and private interest existed in the development of technology to open up the resource, even though U.S. companies actively helped develop the Canadian tar sands resource, estimated to be in the range of 1 to 2 trillion barrels. The U.S. resource, by comparison, is estimated to be roughly 30 billion barrels, with 10 to 20 percent thought to be recoverable, largely by in situ technology.

DOE currently has 22 major field projects underway which are targeted to these different process/reservoir combinations. They include:

Recovery Process	Field Projects	Total Value	Gov. Value
Heavy Oil			
- Thermal	7	$ 53,500,000	$ 18,000,000
Light Oil			
- Chemical	10	$136,800,000	$ 47,700,000
- Miscible (CO_2)	4	$ 14,900,000	$ 6,600,000
Tar Sands			
- Thermal	1	$ 1,500,000	$ 1,500,000
University-Type Support		$ 10,000,000	$10,000,000
Total	22	$216,700,000	$83,800,000

Nearly all projects will be completed in the early 1980s with the latest ones in the 1986-87 period.

In August 1979, DOE announced an incentive program to bring about more rapid commercialization of enhanced oil recovery techniques. This incentive program permits a producer to sell controlled oil at world oil prices if an approved enhanced oil recovery technique is used. A limit of $20 million per project was placed on the incentive, with the intent of encouraging similar types of pilot projects now in progress under the cost-shared program. Up to 100 projects are expected to be started at a cost of up to $2 billion. As of earlier this month, some 61 applications had been received under this program.

In addition, the President has issued an executive order which allows heavy oil to be sold at world prices and has adopted a policy that would exempt some heavy oils from the proposed windfall profits tax.

With these "front-end" incentives designed to encourage field testing of technologies and subsequent production, along with decontrol of heavy oil prices, DOE's FY 1981 R&D program will maintain the same general philosophy as in FY 1980, namely an emphasis on collecting and analyzing data from ongoing field tests (both directly funded and through the new regulations).

- Research will continue to develop new and improved recovery techniques, and small field experiments will be conducted as new techniques are developed to identify problem areas where further research is necessary.

One emerging new area is the investigation in FY 1980 of the mining of heavy oil and tar sands.

The major projects in this activity are shown in Table 12.

TABLE 12

ENHANCED OIL RECOVERY

Research Area/Major Projects	FY 1981 Request
Heavy Oil	$ 7,900,000
Light Oil	$ 5,000,000
Tar Sands	$ 5,900,000

OIL SHALE (FY 1980 - $28,200,000; FY 1981 Request - $36,048,000)

The oil locked in the Nation's abundant reserves of oil shale are a major potential source of energy. Oil from shale is expected initially to be the lowest cost non-petroleum synthetic liquids source. Technology for conventional mining and surface processing of oil shale is believed ready for commercial application, particularly when applied to the 25-gallon-per-ton or greater shales in the rich Western deposits. Commercial development in this area is expected to be encouraged by financial and regulatory incentives.

Present DOE R&D activity is therefore focused mainly on engineering design of commercial-scale surface retort processes to assure the near-term commercial development. The Department is currently negotiating with three firms (Paraho Development Inc., Superior, and TOSCO) for the design of a surface retort module of a full-size commercial oil shale facility.

The principal R&D thrust is to develop underground, or "in-situ", processes which are capable of tapping the leaner and deeper shales with potential cost-savings and lower environmental impact. Priority is given to modified in situ processes, where between 20 and 40 percent of the shale is mined and processed on the surface, with the remainder heated underground.

In addition to the technology base program, including a vigorous effort in environmental R&D, three major in situ field tests are underway via government/ industry cost sharing contracts:

- Occidental Oil Shale, Inc., Debuque, CO -- Preliminary calculations indicate that about 47,000 barrels of shale oil were produced by retort #6, the last test of Phase I. Preliminary mining is underway for access to Phase II, a twin retort test planned for ignition in September 1981, at the same site.

- Geokinetics, Inc, Uintah County, UT -- Retort #17, the largest to date in this project, will be completed in FY 1980 with expected production of at least 4,500 barrels of shale oil. Present plans for FY 1980-81 include two full scale retorts under as much as 90 feet of overburden and a three retort cluster at staggered depths. These would achieve all contract goals.

- Equity Oil Company, Rio Blanco County, CO -- Process adapted to the leached zone in Colorado where normal heating techniques are impractical. Injection of superheated steam to achieve retorting temperatures began in mid-FY 1979, with up to 300,000 barrels of oil expected to be produced during FY 1980 and 1981.

DOE is also working on more novel retorting techniques that are still in the early stages of development, but hold potential for improving current techniques of extracting energy from shale. In cooperation with the Office of Energy Research, the Fossil Energy program is sponsoring work by the IIT Research Institute to adapt radio-frequency heating techniques to oil shale and tar sands. In addition, the Oil Shale R&D program is funding work by the Institute of Gas Technology to develop the HYTORT process, which heats shale in the presence of hydrogen and holds potential for extracting sizeable amounts of synthetic fuels from the lower grade shales.

Major ongoing projects supported by this budget are shown in Table 13.

TABLE 13

OIL SHALE

Research Area/Major Projects	FY 1981 Request
In Situ Conversion	$34,298,000
- Vertical Modified In Situ Debeque, Colorado	
- Horizontal Modified In Situ Uintah County, Utah	
- Solution Mining, Modified In Situ; Rio Blanco County, Colorado	
- Supporting Research	
Surface Conversion	$ 750,000

DRILLING AND OFFSHORE TECHNOLOGY (FY 1980 - $3,000,000; FY 1981 Request - $2,370,000)

The near-term objective of this activity is to increase significantly the domestic drilling rate and to provide instrumentation for Outer Continental Shelf seafloor hazard measurements. This activity will accelerate the commercialization of high performance bits and improved drilling technology and systems, accelerate ongoing seafloor instrumentation data acquisition and dissemination activity to provide useful information to industry and government agencies, and permit initial efforts to determine Arctic onshore and offshore technology requirements.

Drilling and Offshore Technology research activities address the following program objectives:

- o Improve the productivity of conventional drilling systems to increase average penetration rates and thus increase the total footage drilled per year by the U.S. drilling rig fleet;
- o develop longer lived, more efficient, advanced ("revolutionary" as opposed to "evolutionary") drilling concepts;

- o Develop required technology to drill and produce fossil fuels from both on shore and offshore "frontier" areas:
  - very deep formations (greater than 30,000 feet)
  - deep offshore waters (greater than 1,000 feet)
  - Arctic environments
- o Reduce or eliminate any adverse health, safety and environmental impacts of both new and existing technology applications;
- o Coordinate and/or provide direct research support to other development programs both within Fossil Energy, DOE (Geothermal, Energy Research, and Environment) and other Federal agencies (Departments of Interior and Commerce).

Major projects included in this activity are shown in Table 14.

TABLE 14

DRILLING AND OFFSHORE TECHNOLOGY

Project or Research Area	FY 1981 Request
Drilling Research	$ 500,000
Offshore Technology and Seafloor Measurements	$1,300,000
Environmental and Supporting Research	$ 200,000

ADVANCED PROCESS TECHNOLOGY (FY 1980 - $6,000,000; FY 1981 Request - $5,000,000)

The Advanced Process Technology Program has been organized into three principal categories:

- o Advanced Exploratory Research -- including developments in rock mechanics and fragmentation, hydrology studies (the flow and composition of water in an underground formation, and new process concepts such as the use of microorganisms to break down the structure of kerogen in shale and heavy oil into more valuable forms;
- o Product Characterization and Utilization -- focusing on the analysis and characterization of crude oil, heavy oil, and tar sands, including analysis of asphalt as a function of road life;

- Shale Oil Refining and Utilization — continuing studies to enhance the ultimate use of liquid products derived from shale oil and heavy oil, including defining capabilities of existing technology, developing a lower pressure hydrotreating, hydrocracking catalyst; evaluating hydrotreating-physical separation processing schemes, and determining the performance of the fuel products from these refining modifications.

The major projects and funding levels are shown in Table 15.

TABLE 15

ADVANCED PROCESS TECHNOLOGY

Project or Research Area	FY 1981 Request
Advanced Exploratory Research	$2,200,000
Product Characterization & Utilization	$1,300,000
Shale Oil Refining and Utilization	$1,000,000

GAS PROGRAM

Natural gas, despite a 15 percent decline in production in the past five years, remains a majo contributor (25 percent of all energy) to domestic energy supply. Continued decline in gas production will increase reliance on imported oil and gas. If more of this clean, versatile fuel becomes available, the decline could be offset and gas could be diverted to industrial users of oil, thus reducing oil imports

The producible, proven U.S. natural gas reserves are about 200 trillion cubic feet. There is a large degree of uncertainty about the extent of the remaining undiscovered conventional, high cost gas in the U.S. Resolution of this uncertainty during the 1980s will evolve slowly. But a potentially significant impact on proved reserves additions can be made if the technical constraints and risks which deter private investments in the already discovered unconventional resources can be mitigated.

Four large unconventional gas resources have been identified as having significant potential for development and positive impact on future supplies. These are:

- Tight gas-bearing sandstone and limestone formations. Existing in blanket and lenticular formations in the Rockies, Northern Great Plains, and the Southwest. Estimates of the gas in place range from 400-1,000 trillion cubic feet, about one-fourth to one-half of which might be recoverable. Almost 90 percent is in lenticular formations which is currently not economic to produce with present technology.

- Gas-bearing Devonian and Mississippian shales. Located in the Applachian, Michigan and Illinois Basins, with an estimated resource size between 200 and 2,000 trilliion cubic feet (depending on whether free gas or absorbed gas is counted), about 10-20 percent of which might be recoverable;

- Natural gas trapped in coalbeds. Technologies for recovering methane from coalbeds in conjunction with mining are relatively well-developed; however, the more attractive, longer term target is recovery from unmineable coal seams, for which considerable technology development and increased fundamental knowledge is required;

- High-temperature, high-pressure (geopressured) aquifers. Existing in the Gulf Coast region. Geopressured aquifers are not included in this discussion because they are the responsibility of the Assistant Secretary for Resource Applications.

The Enhanced Gas Recovery program in Fossil Energy is a relatively recent program which grew from as little as $3.9 million in FY 1975 to its current level for FY 1980 of $35.6 million. Throughout this period, the major portion of the R&D has been directed at the Eastern Devonian shale, and as recently as 1977 the R&D programs funds devoted to coalbed methane were very small and primarily focused on recovery in conjunction with mining.

During the past two years, based on the findings of recent studies of the potential of these resources and the Natural Gas Pricing Act, DOE has developed a regulatory and incentives program for these resources. Eastern Gas Shales and coalbed methane are completely deregulated and Tight Gas Sands will receive a high cost gas incentive price per the pending FERC regulations. These incentives could lead to a number of privately financed projects.

Therefore, the Federal role in R&D is to foster activities which enhance understanding of the basic reservoir behavior and stimulation processes, improve predictability and reliability of results and to provide for effective information transfer. Specific focus will be on developing the tools to better define gas-bearing reservoirs and the development of advanced, high efficiency fracturing and recovery techniques.

Funding requests for the Gas R&D activities included in the FY 1981 budget total $30,821,000. The gradual decrease in this area is due to concentration upon completion of basic resource characterization studies and therefore, a reduction in the number of field demonstrations planned for the coming fiscal year.

- Major projects are shown in Table 16.

TABLE 16

ENHANCED GAS RECOVERY

Research Areas/Major Projects	FY 1981 Request
Eastern Gas Shales (OH, WV, KY, VA)	$12,400,000
Western Gas Sands (UT, CO, TX)	$12,400,000
Methane from Coalbeds (PA, UT, AL, WV)	$ 5,000,000
Environmental Support	$ 248,000

INTERNATIONAL PROGRAMS

The Office of Fossil Energy, through joint international activities, seeks to provide information useful to U.S. energy research programs and to provide any opportunity for other countries' participation in U.S. research efforts. The purpose of this program is not to develop energy technologies specifically for other countries because all of the projects listed as international efforts are part of domestic R&D programs. They are not identified as separate line items in the President's budget.

Fossil Energy's International Programs establish a vital link between foreign and domestic technologies, providing opportunities for early and economical introduction of new and promising (and possibly unproven) fossil energy technologies in the U.S. Joint exchange of information prevents unnecessary duplication of technical activities and gives insight into choices of technologies that have had varying degrees of success or acceptance abroad. Cooperative international programs permit the acceleration of Fossil Energy R&D by participation in the development of untried technologies, with a sharing of both the technological risks and the costs of participation. Moreover, by evaluating foreign technologies, their potential for commercial applicability in the U.S. economy can be established.

Cooperation may be bilateral, multilateral, or government/industry. International cooperative agreements range from information exchange to major demonstration projects. Many are carried out in cooperation with the International Energy Agency (IEA). The joint technology development and demonstration projects are significant in that they allow for substantial participation by private industries. The participation of U.S. personnel in joint projects abroad not only gives the U.S. the opportunity to assess foreign technologies in their own social and economic environments, but also provides proven means for technology transfer to the U.S.

Major international projects are:

Project	International Participants
Coal	
o Solvent Refined Coal-II Demonstration Plant	Federal Republic of Germany Japan
o Exxon Donor Solvent Pilot Plant	Federal Republic of Germany Japan
o Pressurized Fluidized Bed Combustion of Coal (IEA Agreement)	United Kingdom Federal Republic of Germany
o Magnetohydrodynamics	Poland, U.S.S.R., Netherlan
o Coal Oil Mixtures (IEA activity)	Canada
o Coal Mining and Utilization	Australia Federal Republic of Germany United Kingdom U.S.S.R. Poland
o Mining Technology Clearinghouse (IEA Activity)	Seven IEA countries
o Economic Assessment Service (IEA Activity)	Nine IEA countries
o Technical Information Service (IEA Activity)	Eleven IEA countries

Oil	
Enhanced Oil Recovery (IEA Activity)	Six IEA countries
Enhanced Oil Recovery	U.S.S.R.
Tar Sands	Canada
Natural Gas	
Enhanced Gas Recovery	U.S.S.R.
Combustion	
Energy Conservation in Combustion (IEA Activity)	Italy Sweden United Kingdom
Heat Transfer	
Heat Transfer Systems (IEA Activity)	Sweden Switzerland United Kingdom

With respect to ongoing agreements with the U.S.S.R., the Office of Fossil Energy is cooperating in carrying out the President's policy in the area of exchange of technology. We shall not resume "business as usual" until the President confirms improvement in the political situation.

BUDGET SUMMARY

To assist in the review of the Fossil Energy Program, a summary table (Table 17) is presented with displays, by resource and activity, the FY 1981 budget request.

TABLE 17
DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY

SUMMARY BY ACTIVITY
(Budget Authority; Dollars in Thousands)

COAL	FY 1980	FY 1981 Request
Coal Mining	$ 68,850	$ 46,500
Coal Processing		
o Coal Liquefaction	250,306	523,900
o Coal Gasification	115,850	138,500
o In Situ Gasification	10,000	10,000
Subtotal	376,156	672,400
Coal Utilization		
o Combustion	50,850	68,500
o Fuel Cells	26,500	25,000
o Heat Engines & Heat Recovery	50,500	43,400
Subtotal	127,850	136,900
Advanced Environmental Control Technology	38,250	42,500
Advanced Research & Tech. Development	56,150	64,461
Magnetohydrodynamics(MHD)	75,000*	72,000
Program Direction	11,387	12,145
TOTAL COAL RESOURCE	753,643	1,046,906
PETROLEUM		
Enhanced Oil Recovery	23,100	19,400
Oil Shale	28,200	36,048
Drilling & Offshore Tech.	3,000	2,370
Advanced Process Technology	6,000	5,000
Program Direction	781	940
TOTAL PETROLEUM RESOURCE	61,081	63,758

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*Does not include $17,500,000 supplemental

GAS		
Enhanced Gas Recovery	35,310	30,548
Program Direction	276	273
TOTAL GAS RESOURCE	35,586	30,821
TOTAL FOSSIL ENERGY (Direct Appropriations)	850,310	1,141,485

Senator MATSUNAGA. Thank you very much, Mr. Secretary.

I was out at the Lawrence Livermore Laboratories and spent about a day out there looking over the facility. One of the things that really struck me as a very promising source of energy was the in situ coal gasification process. At one time, I understand, the Department of Energy saw some real problems in this and I suppose you still do.

However, I note in your budgetary request you have only $10 million set aside for this program for fiscal year 1981. I would like to hear your comments on this.

Mr. FUMICH. We believe in situ coal gasification technology is one of the programs we should develop. On the other hand, we consider in situ coal gasification technology not a near-term technology. It is a technology that I would say may be in the first third of its development process, maybe a little more. We still have more work to do with that particular technology.

So far, the coals that we find that work best with in situ coal gasification technology is the noncaking, more reactive Western coals. Western coals is that in developing either medium Btu gas or the low Btu gas for the in situ coal gasification technology. This presents a problem with utilization.

With the low Btu process, you have to find a market very close to the gasification site. You can't transport the gas any distance. Medium Btu gas can be transported within a radius of 100 miles or converted to other possible uses and this helps that situation somewhat. However, this is one of the problems we have with in situ gasification.

Plus, we still have not answered all of the environmental problems. Unless you get into a big burn, you can't determine the environmental impact very well. The other part of the coin is that we have constraints on how much money we can spend in this area, which is only proper. We have felt that within the FE priorities that our request constitutes a reasonable level of funding.

Senator MATSUNAGA. I understand the Department of Energy requested proposals be submitted to the Department from industry and did receive proposals on in situ coal gasification, but rejected all of them. Do you happen to know why?

Mr. FUMICH. Sir, you may have some different information than I have. My understanding is that possibly our criteria were not really proper for the industry.

We were requesting 50 percent cost sharing and my understanding is that the receipt of proposals was not what we had anticipated. As a result of that, we had a negative situation with the Program Opportunity Notice (PON). Possibly we may have overspecified what we expected from the industry. The proposers did not meet those specifications in the PON.

In any event, this goes back to my original statement on the state of the technology. We are really not all that far down the road in this technology. Evidently, by requesting 50 percent cost sharing, industry felt the same way or they would have come in with that kind of cost sharing. My understanding was that they didn't meet the cost-sharing criteria.

Senator **Matsunaga**. As I understand it, the Department of Energy is also requesting $10 million for the in situ coal gasification project from the windfall profit tax measure. Is that correct?

Mr. **Fumich**. Yes, sir.

Senator **Matsunaga**. Is that in addition to the $10 million?

Mr. **Fumich**. That would be in addition to the $10 million we have in our regular funding request. May I make a comment on that, sir?

This does not mean that these items are not as high a priority as those in our direct line request. We were trying to use every legitimate approach that we thought was a proper request for our program.

Senator **Matsunaga**. How do you intend to use this additional $10 million?

Mr. **Fumich**. If the funding is approved, we would try to go out with another PON and possibly a different approach. Perhaps the cost-sharing approach would be reviewed as well as the specifications in the original PON, chances are we will take another look at the cost sharing.

We would talk to private industry to get their point of view on reasonable criteria for the PON. I think that these are the things we would do differently with the additional $10 million.

Senator **Matsunaga**. The reason I am so interested in coal gasification is because, as I have been told, this would be one of the safest methods of coal conversion, and it would have the least impact on the environment. Because of concerns about coal burning causing environmental problems, I thought this would be the project with which you would proceed full speed ahead without running into the obstacles normally placed by the Environmental Protection Agency.

Mr. **Fumich**. Sir, we agree with your thinking. The technology does have a lot of pluses. It would be more environmentally benign than many of the other things we are doing because everything is underground. Possibly if we went the medium Btu gas route, we could supplement our gas supplies and possibly through an indirect liquefaction process convert the gas to liquids. Or possibly convert the gas to a high Btu gas. In our view, this could be more economic because you would not need all the capital investments that you would require with a totally surface gasification facility.

Like all other technologies in situ gasification has problem areas and I think the problem areas that I addressed adversely affected that first PON. I believe if we reassess the criteria that we used by talking to the industry and look at this whole situation again, we may have a much more favorable response with the next PON, sir.

Senator **Matsunaga**. I will be looking forward to your activities in this area. I have many other questions, but I don't want to take all the time. Senator Melcher, do you have any questions of Mr. Fumich?

Senator **Melcher**. Is the MHD program on schedule with the Department's research and development?

Mr. **Fumich**. Sir, I don't think the program is on schedule. The original target date we had for commercialization of MHD power systems was around the year 2000. I think the proposed strategy, which involves increasing the size of the CDIF from its present 50 megawatts to between 85 and 100 megawatts and increasing the size of the ETF from 250 to 500 megawatts will accelerate the commercialization by 5 years. This is an aggressive MHD program, yes, sir.

Senator **Melcher**. Is it ahead of schedule?

Mr. **Fumich**. It is not ahead of schedule, sir.

Senator **Melcher**. Well, you have revised the schedule, you have shortened the schedule?

Mr. **Fumich**. Our revised schedule would expedite or shorten commercialization by at least 5 years. Just as important, the commercialization schedule is more important than the funding requirements down through the years. In this development program strategy which requires a two-stage rather than a three-stage program, we cut out the need for the 1,000 megawatt MHD demonstration plant required in the former approach and save almost $1 billion by doing that.

The whole program will be much less expensive, but I don't think that part is as important as making the MHD commercialization schedule shorter. The other, of course, is nothing to sneeze at.

Senator **Melcher**. The schedule has been advanced?

Mr. **Fumich**. Yes, sir.

Senator **Melcher**. The time frame commercialization has been cut short?

Mr. **Fumich**. Yes, sir.

Senator **Melcher**. You said a million dollars. Did you mean a billion dollars?

Mr. **Fumich**. If I said a million, I meant a billion dollars.

Senator **Melcher**. Is it true that there has been a breakthrough in one of the processes or a phase of the process that was announced in September? I believe this involved superheating with injection of oxygen?

Mr. **Fumich**. Yes, I'm glad you brought that up, Senator. Some of the people who are involved in putting this together, were wondering how we could increase the size, in effect double the size of the ETF to commercial prototype scale without raising the development risk to more than an acceptable amount. Using the oxygen enrichment approach that you mentioned takes away significant added risk. By doing that, the need for high temperature air heaters in early commercial plants is eliminated, and we can go to this larger size with almost the same amount of risk that we would have in scaling from the 50 megawatt systems to a 250 megawatt size ETF.

Senator **Melcher**. Is there solid reason to believe that conservation of coal will result? The figures I have are that 40 to 50 percent of the coal consumed in a conventional steam generating method can be saved by using the MHD process to generate the same amount of electricity.

Mr. **Fumich**. Very, very solid, sir. If you just check the efficiency achievements and limits of the present technology we are using in this country today, it is easy to extrapolate and find out where we get that saving. The efficiency most modern pulverized bed utility boiler today, coal-fired without a scrubber the way they have been in the past is about 34 or 35 percent.

You have to realize that what that means is that of the thermal energy in a ton of coal, only about 34 percent is converted to electric power. In other words, you get about one-third coming out as you put in. On the other hand, if the net plant efficiency is increased 50 percent or more, there is a tremendous reduction in lost energy.

On a national scale, if you can increase efficiency by 1, 2, or 3 percent, you have a tremendous achievement. If you can go up to around 50 percent, that means you are really saving millions of tons of coal annually which means, of course major cost savings and a reduced burden on railroads.

In addition, the less coal you burn, the less pollution you will have. With MHD, emissions are reduced. It also does a better cleanup job on the other of the system, resulting in a compounding, positive effect. That's one of the reasons we believe it is important to develop and maximize use of the MHD technology.

Senator **Melcher**. Coalstrip 3 and 4, the latest approved plants are under construction in Montana and they entail scrubbers. I believe the efficiency is about 32 percent. Is that correct?

Mr. **Fumich**. I would say that would be the range, yes, sir.

Senator **Melcher**. Is it still reasonable to believe, that with the MHD technology, using the same coal, you can increase efficiency above 50 percent?

Mr. **Fumich**. Yes, but I want to make sure that what I say is completely correct. Now, the first generation plants would not go up that high. We are talking about large scale second generation commercial systems where the technology, has been completely tested for the 50 percent efficiency level.

The systems we are developing right now, even the first MHD commercial plants would still go up over 40 percent but would not reach the 50 percent mark. This is a reasonable target for the technology when it is completely commercialized, yes, sir.

Senator **Melcher**. When you mention 250 megawatts, are you talking about 250 megawatts thermal or 250 megawatts——

Mr. **Fumich**. This is thermal.

Senator **Melcher**. Thermal. Would that reduce itself to about 50 megawatts of electricity?

Mr. **Fumich**. About 80 megawatts of electric power.

Senator **Melcher**. Eighty megawatts of electricity is not a commercial size.

Mr. **Fumich**. You have to double that——

Senator **Melcher**. That is the point I want to make. Would doubling that 260 megawatts of electricity be considered——

Mr. **Fumich**. Yes, sir, it would be a very good size. Doubling the ETF size from 250 MWt to 500 MWt would increase output from 80 MWe to about 200 MWe due to greater efficiency.

Senator **Melcher**. Under the program, are we aiming for a half-size commercial or demonstration facility?

Mr. **Fumich**. Yes.

Senator **Melcher**. Is it still reasonable to believe, or is there any reason to doubt, that the MHD technology would remove, first of all, any problem in meeting Federal standards for sulfur dioxide emissions?

Mr. **Fumich**. No, sir. The effluent would be clean.

Senator **Melcher**. Does that remove the threat of acid rain from such a plant?

Mr. **Fumich**. Not completely. Anything that burns carbon will cause some of that problem. The way it would make a big dent in the problem is like I mentioned, you would be burning less fuel for the equivalent amount of electricity, and would also have reduced emissions in an absolute sense. So you have a compounding, positive effect.

Senator **Melcher**. How about nitrogen in the MHD process? Is there any reason to feel there would be any difficulty in meeting Federal standards?

Mr. **Fumich**. I don't think so, no, sir. You would have the same example with nitrogen.

Senator **Melcher**. Would the same be true of fly ash?

Mr. **Fumich**. Yes, all the way across the line.

Senator **Melcher**. Then would there be a lot less water also?

Mr. **Fumich**. Yes, sir.

Senator **Melcher**. In comparing conservation, the environmental problems and water requirements, MHD is far superior. Are there a number of parallel research and development programs that touch on the problems you have in making sure that the MHD engineering and component systems are correct? Are there a number of parallel problems with other R. & D. programs?

Mr. **Fumich**. We have different efforts by different companies. We are trying to use more than one option to attack a certain problem. If one does not work well, we have assurance that another method can be used to solve the problem.

In MHD combustion development, we have about three different research programs going on by different companies. This is the same way in which we are attacking the channel problems. We have different groups involved. The other thing that should be surfaced here is the advancement of the program, from one of a research program to an engineering program. Plus, instead of leaning as we did years ago on universities, we are getting big companies involved in the program. We think this is critically important. In the final analysis, these are the people who will have to develop, manufacture, and utilize the technology we are talking about.

Senator **Melcher**. I notice that for surface gasification there is a request for $138,500,000 for fiscal year 1981. Is this being done as part of the proposed commercial plant in North Dakota?

Mr. **Fumich**. Sir, the technology proposed to be used in Beulah, N. Dak. is a technology developed in Europe and Germany and utilized in the rest of the world. That technology, although we believe commercially adaptable in this country today, does have some problems associated with it.

The Mercer County project uses Lurgi technology which cannot use Eastern caking coal. Units can only go to a certain size which means you have to replicate quite a few units. Also, the product slate is not very flexible. It's very difficult to get a product slate amenable to a regional usage pattern.

As a result, it will be a little more expensive, we believe, than some of the technologies we are developing. By saying that, I don't mean that we should not use that technology. I believe we should use any technologies we have.

I believe we ought to start today with the synfuels industrial program. This is one of the pioneering efforts we believe is essential in order for the synfuels industry to make a dent in our future supply problems.

We either have to modify that particular technology or develop other technologies so that we can use not only the noncaking, more reactive Western coals, but the caking, less reactive Eastern coals. This is what our synfuels program is all about.

Senator **Melcher**. When you said national, I assumed you did not mean owned and operated. You just meant it would be used on a national scale. Is that correct?

Mr. **Fumich**. Yes, sir.

Senator **Melcher**. The request for liquefaction, is over half a billion dollars. Is that for a plant in West Virginia and one in Kentucky?

Mr. **Fumich**. Sir, the liquefaction program includes $57 million for our H-coal process pilot plant in Kentucky, $32 million for the donor solvent pilot plant project in Texas, $180 million for the SRC I project in Kentucky, and $195 million for the SRC II project in West Virginia. These are the main increments of the coal liquefaction funding request.

Senator **Melcher**. Is it believed this money would be advanced to these plants, and the Government would run them?

Mr. **Fumich**. Sir, these are cost-shared plants that we have moved ahead from the early days in which a proposal comes in with a process that either industry or the Government developed. The industry partner supplies money on the front end, and the Government does, too.

These projects are not what I would call commercial projects. In other words, it's not the same as we had in Beulah, N. Dak. In my opinion, that is a commercial-type facility. I don't believe any of the projects I mentioned would be funded by industry unless the Government came in with front end money to develop the technology. This is the objective of the Government funding.

The two SRC plants will be commercial-size modules of a proposed commercial plant but there are still enough question marks regarding the SRC technology that those particular proposers would never, in my opinion, go to an agency like the proposed Energy Security Corporation for funding and say they want a guaranteed buy or minimum price on a barrel of the product. I don't think that would happen and this means the Government has to assist on the front end with part of the risk.

The H-coal project in Kentucky at either the 600-ton-a-day level and the Exxon donor solvent—EDS—plant at the 250 ton level, can proceed into a commercial arena without going to the demonstration plant scale. The reason for this is the SRC technologies are ahead of that and will bear the brunt of all the problems you will have when you build something at commercial scale.

Believe me, there will be problems. Although we are confident after awhile the technologies they will work, we do expect to have problems in the operations and development of those particular processes. Otherwise, we would not be in the business of trying to demonstrate the processes at those particular scales.

We believe it is important to have more than one process because, of the varieties of coal. I have found out coal is a jealous mistress. You can get the same seam of coal over a period of 150 miles, and that seam will work with a process. In another area, it will not work with the same process. In another area, it will work even less.

If this happens with one seam of coal, you can imagine what will happen over the country with different types of coals.

Senator **Melcher**. Thank you.

Senator **Matsunaga**. Senator Bellmon.

Senator **Bellmon**. Thank you, Mr. Chairman. Mr. Secretary, I would like to ask some more questions along the line that the Senator from Montana was pursuing. I must say to you that I favor the Government taking the lead in getting coal liquefaction technology moving. We have waited too long and we could be using our coal resources more than we are.

Assuming that we approve the funding you have requested, how long before production could be expected from SRC I and II?

Mr. **Fumich**. Based on the present schedule we have, sir, the plants would be constructed in 1984, and we hope would have successful operations of those plants. Then we could start to design the commercial plant before the operations of the demonstration plants are concluded. Still a meaningful operation is necessary before you can go full bore into planning and building a commercial plant. If the demonstration plants worked, of course, you could add more units to those particular facilities and have a commercial facility with commercial production. However, that would take another 2 years at least.

Senator **Bellmon**. These are 6,000 tons a day plants?

Mr. **Fumich**. Yes, sir.

Senator **Bellmon**. You figure about 5 barrels of oil per ton of coal?

Mr. **Fumich**. No, sir, for most of our technologies the range would be anywhere from a barrel and a half to 3 barrels per ton of coal. You have to compare that with oil shale where you get maybe 25 gallons to 35 gallons of oil per ton of shale in the richest deposit.

Senator **Bellmon**. You can't very well burn shale but you can burn coal. What are the byproducts, would you get methane out of it?

Mr. **Fumich**. You will get naphtha, high Btu gas, fuel gas——

Senator **Bellmon**. How much gas per ton?

Mr. **Fumich**. I would say as far as the ratio is concerned, it would be 35 to 40 percent. We can give you the product slates for the record.

[The requested information follows:]

SRC I AND II DEMONSTRATION PLANTS

The product slates for the SRC-I and SRC-II demonstration plants are shown below based on 6,000 tons of coal per stream day. The 6,000 tons represents feed to the plant with part of this feed diverted to hydrogen production. Added together, the energy equivalents of all the products from each SRC demonstration plant total approximately 20,000 barrels per day.

SRC-I

Naphtha, 1,500 barrels; fuel oil, 3,145 barrels; solid fuel, 1,800 tons; and anode coke, 620 tons.

SRC-II

Naphtha, Consumed as plant fuel; fuel oil, 10,350 barrels; liquefied gases, 3,550 barrels; and pipeline gas, 47 million standard cubic feet.

Senator BELLMON. I never see these things that are introduced into the record. Would you give me a copy for my own?

Mr. FUMICH. Yes, sir.

Senator BELLMON. If you will mail it to me, it would be fine. You are talking then about initial production of around 10,000 barrels a day per plant?

Mr. FUMICH. About 6,000, from that particular technology to produce 20,000 barrels of oil equivalent per day.

Senator BELLMON. That's over 3 barrels per ton?

Mr. FUMICH. I would say 18,000, barrels of oil equivalent per day. I'm a little more conservative.

Senator BELLMON. 18,000, that's just 1 module?

Mr. FUMICH. That's 1 module. We figure maybe you would have 5 modules per commercial plant.

Senator BELLMON. You're getting up close to 100,000 barrels a day?

Mr. FUMICH. Yes, sir.

Senator BELLMON. Can you expect that kind of production by 1986?

Mr. FUMICH. No, sir.

Senator BELLMON. When?

Mr. FUMICH. I would expect that kind of production, and I would rather give you a range than a year, in the late 1980's.

Senator BELLMON. 1990, we will say?

Mr. FUMICH. Yes, sir.

Senator BELLMON. You hope if things go well, by 1990 you will have one plant or two?

Mr. FUMICH. It would depend, sir, on industry participation and on the success of the plant.

Senator BELLMON. They can't build the commercial plant until you have demonstrated the technology?

Mr. FUMICH. Yes, that's what I'm saying. You would have two plants at that particular time.

Senator BELLMON. In 1984 you will get a demonstration plant in operation?

Mr. FUMICH. Yes, sir.

Senator BELLMON. You want to run it awhile so maybe by 1986 you can start on your commercial plant?

Mr. FUMICH. I would say yes, that's reasonable.

Senator BELLMON. It would take 3 or 4 years to build it?

Mr. FUMICH. Yes, that's 1995——

Senator **Bellmon**. Where will we get this 2½ million syncrude the President is talking about?

Mr. **Fumich**. That will come from a range of technological processes.

Senator **Bellmon**. This is the most advanced thing we have going?

Mr. **Fumich**. No, sir, it's not the most advanced.

Senator **Bellmon**. You haven't done anything with oil shale?

Mr. **Fumich**. I think the most near-term is oil backout of utilities.

Senator **Bellmon**. Let's not kid ourselves, that's not synthetic fuel. He talked about 2½ million barrels a day of synthetic crude by 1990. As far as I know, this is the closest we are to getting synthetic crude from any source.

Mr. **Fumich**. I think something earlier would be indirect liquefaction. In other words, the same technology that will be used for the Beulah, N. Dak., high Btu gas plants can be used for indirect liquefaction. This would depend on private industry participation and how fast they want to come in with projects, either with guaranteed loans or the guaranteed buy of plant production.

Senator **Bellmon**. Is this the SASOL technology from South Africa?

Mr. **Fumich**. Yes, sir.

Senator **Bellmon**. No one is building one of those, are they?

Mr. **Fumich**. I understand there are proposed announcements concerning medium Btu gas projects that would not be exactly equivalent to SASOL but pretty close. These would be in the Gulf Coast region and other parts of the country. These would be private endeavors.

Senator **Bellmon**. Do you happen to have any details about any private company?

Mr. **Fumich**. I don't have any details, sir. From unimpeachable sources, I understand one might be in the Texas Gulf region——

Senator **Bellmon**. Using coal as the feedstock?

Mr. **Fumich**. Yes, sir, coal as the feedstock.

Senator **Bellmon**. I didn't realize the Texas Gulf had any coal plants.

Mr. **Fumich**. They have lignite, sir, but the Louisiana facilities would be using coal shipped down the Mississippi River. I understand this coal more than likely——

Senator **Bellmon**. What I was trying to get a fix on was how close we are to getting some meaningful production from synthetic crude. In spite of all your hopeful suggestions about what others may be doing, the Department doesn't have anything in sight before 1990?

Mr. **Fumich**. Sir, as far as our particular program is concerned, we are not going to reach that target. I might as well be candid about it right here. I would not even want to speculate that we are going to reach that target. We have a fairly clear understanding about what the time frame will be for achieving our goals.

It's going to depend, I think, a lot on what happens if the Energy Security Corporation is enacted into law and how many people come in with different projects. I think that part of that target will be supplemented by EOR, some by EGR.

Senator **Bellmon**. I don't understand what that is.

Mr. **Fumich**. Enhanced Oil Recovery and Enhanced Gas Recovery.

Senator **Bellmon**. That's not syncrude, enhanced oil recovery is going on all the time. We're talking about syncrude.

Mr. **Fumich**. I understand that the 2½ million target included these resources.

Senator **Bellmon**. No, it was synthetic crude production.

One last thing, Mr. Chairman, if you have any specifics about projects the private sector is currently constructing, I'm not talking about planning, not a lot of if's and but's and and's, but if you know synthetic crude plants about to go onstream, would you also let us have that for our record?

Mr. **Fumich**. Sir, I'll give you for the record a breakdown of the 2.5 million barrel per day target and a list of the projects that we understand maybe coming on line in the next few years.

[The requested information follows:]

Mix of Synfuels Sources to Meet 2.5 MMB/D Goal

The Energy Security Corporation as proposed by the President, would determine the exact mix of the sources and technologies which will be used to meet the 2.5 million barrel per day target. The following table however, shows an illustrative division of sources for meeting the target:

	Million barrels per day
Liquids and gases from coal	1 to 1.5
Liquids from oil shale	0.4
Liquids and gases from biomass	.1

In addition, a $50/thousand cubic feet tax credit is proposed to stimulate commercial production of unconventional gas. Projections for contributions for this energy source, expressed in million barrels per day equivalent, is:

	Million barrels per day
Unconventional natural gas	0.5 to 1

Senator **Bellmon**. I have seen reports that go for pages and pages about things that may someday happen. What we are really interested in are specifics, cases where someone is spending money or pouring concrete or where there is actually construction underway.

Mr. **Fumich**. We will do that, sir.

[The requested information follows:]

Synfuels Projects Underway

Activity on synfuels projects has been reported publicly as follows:

TVA is nearing completion of a coal gasification unit to manufacture synthesis gas at Muscle Shoals;

EPRI, Texaco, Southern California Edison, and General Electric have announced a project for a coal gasification—combined cycle electric generating facility at Coolwater, CA;

Tennessee Eastman has announced a project to make chemicals (including methanol) by coal gasification followed by chemical synthesis steps;

Dow Chemical has announced that it is constructing a coal gasification system for fuel gas generation at a Gulf Coast plant;

The Great Plains Coal Gasification, headed by American Natural Resources, project in North Dakota, which has FERC approval, is designed to produce SNG from lignite for commercial distribution;

The Memphis medium-Btu gasification demonstration project, recently selected by DOE for further support, will provide fuel gas to municipal customers;

The W. R. Grace Company plans to use DOE support to complete the initial design work for a 50,000 BPD indirect coal liquefaction plant.

Texas Eastern Corporation announced on October 2, 1979, that it had reached an agreement with SASOL, Ltd. (South African Coal, Oil and Gas Ltd.), in cooperation with Fluor Corporation, to obtain technical assistance to construct a coal-based synfuels plant in the U.S., and is currently considering several locations in the Ohio River Valley, among others, as the plant site.

Conoco Inc. and five partners have started work leading to construction of a medium-Btu coal gasification plant in Louisiana.

W. R. Grace is funding work which could lead to a plant in northwest Colorado producing 5,000 tons of fuel grade methanol per day.

Indications are that a number of proposals for coal gasification and indirect liquefaction for feasibility studies and/or cooperative agreements will be received in response to the initial solicitations under PL 96-126 (Alternative Fuels Act). These projects, as well as some of those on the above list (e.g. the W. R. Grace project), will require further funding or incentives of the type envisioned for the Energy Security Corporation before the production of synfuels can be assured. Nonetheless, sufficient information is available to foresee the start of commercialization when incentives and financial situations are favorable. We believe that successful completion of the DOE program of large pilot and demonstration plants for coal liquefaction and gasification technologies will further accelerate commercialization activity. The increased efficiencies and reduced technical and economic risks resulting from the DOE program will be important in promoting commercialization to meet the Nation's energy goals.

Senator **Bellmon**. That's all I have, Mr. Chairman, thank you.

Senator **Matsunaga**. Thank you, Senator Bellmon.

Mr. Secretary, on November 1, 1979, FERC removed price controls from natural gas produced from geopressurized brine, coal seams and devonian shale. What has been the result of that decontrol in terms of activity in these areas and production of gas?

Mr. **Fumich**. Sir, we don't have the facts coming in from that yet, but we understand there is much more activity, particularly in the other fronts. I'm not sure about geopressurized methane—that's not in my program—but if we have to base it on what is coming through on enhanced gas recovery and what has come through to date on enhanced oil recovery, it's too early to tell, really, how these actions by FERC will impact gas production.

We don't have the information yet because industry has just started coming into those programs. For instance, in enhanced oil recovery, there figures to be about 100 proposals coming in and so far they've had 64. Those particular programs have just been started and it's too early to tell what the impact of those particular programs alone will do. We feel these are very positive steps.

Senator **Matsunaga**. Columbia Gas, as I understand it, recently announced a large $450 million program in Appalachia to drill some 3,500 wells on one-half million acres in northwest Pennsylvania and New York. Do you happen to know what the status of this project is?

Mr. **Fumich**. We've had programs with Columbia Gas in previous years but we are not involved in that particular program. Columbia Gas has been involved in devonian shale production for many years. They have a very strong program in that area.

The problem with devonian shale is that you get very little production from the devonian shale well as compared to a regular natural gas well. The reason for that is that the devonian shale is so compacted that you have production over a much longer period but production over a year is much smaller. As a result, it just does not pay back on the same investment as quickly as these other areas and that's the reason we feel these new actions will in fact result in a greater contribution from this area.

Senator **Matsunaga**. Do you feel that there is a genuine incentive for production when we decontrol?

Mr. **Fumich**. Yes, sir. I think it's obvious that when the selling price is greater then the investment can be amortized at a faster rate. Let's face it, everyone involved in any of these areas has a profit motive and the profit motive is what made this country great.

I believe these incentives will result in quicker production. That doesn't necessarily mean there will be greater total production. We believe that a combination of a front end government research program on a high risk, high payoff technology combined with the increased prices and market incentives will give us much greater production.

For instance, in enhanced oil recovery my people say if you go just with higher prices and existing technology, companies will use the existing technology to bring production out of the heavy oils and also the light oils more quickly. Over the long-term, recovery will not be greater. On the other hand, if you use higher risk-greater payoff technology in some cases, the estimates are that by the year 2000 you will get 2 million barrels a day more. This is just an illustration.

Senator **Matsunaga**. We have quite a few more questions, Mr. Secretary, but we are pressed for time.

Mr. **Fumich**. I'm sorry to hear that, sir.

Senator **Matsunaga**. We would appreciate your responding for the record. We will have the questions submitted to you in writing.

Mr. **Fumich**. Yes, sir.

Senator **Matsunaga**. So unless—oh, I did not notice, Senator Bumpers has come in.

Senator **Bumpers**. I will pass, Mr. Chairman, I just got here.

Senator **Matsunaga**. Any further questions?

Senator **Bellmon**. Mr. Chairman, may I ask just one question?

Senator **Matsunaga**. Yes.

Senator **Bellmon**. Mr. Secretary, looking at the budget, I find there is $175 million for SRC-1 and $109 million for SRC-2. You are having to find that money someplace in the budget. Can you tell us where you are cutting back?

Mr. **Fumich**. No, sir, I can't tell you at the present time where we are cutting back because we don't know where these cuts will be made ourselves in many instances.

Senator **Bellmon**. But you will have to cut back?

Mr. **Fumich**. I would assume, yes, sir.

Senator **Bellmon**. I'm talking about the money you are putting into SRC-1 and 2.

Mr. **Fumich**. Oh, I didn't say we would be cutting back there, sir.

Senator **Bellmon**. Have you added to your budget enough money to cover those outlays?

Mr. **Fumich**. Sir, we are requesting what money we think will be necessary for the next year.

Senator **Bellmon**. But your total budget is not up that noticeably over previous years?

Mr. **Fumich**. Our budget is up much higher than last year. Last year it was $850 million for coal and now it's over $1 billion.

Senator BELLMON. I'm talking about your total budget. What was the total budget for DOE in fiscal year 1980?

Mr. FUMICH. Our total budget in fiscal year 1980 was about $850 million.

Senator BELLMON. For the whole Department?

Mr. FUMICH. Oh, the departmental budget was about $10 billion.

Senator BELLMON. What is it for 1981?

Mr. FUMICH. $12.6 billion.

Senator BELLMON. How much of that is for SPRO?

Mr. FUMICH. I don't think they're asking any money this year for SPRO, although we can check. We have the DOE budget here.

Senator BELLMON. What's the 2.6 increase for, that's a big jump.

Mr. FUMICH. As far as the total DOE budget——

Senator BELLMON. We'll look into it ourselves, but as far as you are concerned, you have made additional requests for the money you are going to be expending in SRC-1 and 2 and you are not cutting back other essential programs?

Mr. FUMICH. No, sir.

Senator BUMPERS. Mr. Chairman, if I might ask one question. What is the difference between gasification of coal underground and on the surface as far as cost is concerned, do you know?

Mr. FUMICH. Gas from underground coal gasification would be cheaper. You don't need all the facilities that you have to have for a surface facility and as a result of that, you would have fewer environmental problems to deal with requiring capital expenditure. This is one of the reasons we think underground coal gasification is something we should pursue. But it is technology that is not nearly as well developed as some of these other areas. This is the reason we want to move forward in this area. It will take us a little more time before we can do better than to use assumptions about the technology involved.

Senator BUMPERS. Two other questions. In conversion of coal to high gas, how much of the Btu value of coal do you lose?

Mr. FUMICH. I would say efficient processors would convert about 70 percent of the Btu value of coal.

Senator BUMPERS. For high gas?

Mr. FUMICH. Yes, sir.

Senator BUMPERS. How about for low gas?

Mr. FUMICH. I would have to get you that figure. I can't guess on that.

Senator BUMPERS. Less than that, would you think?

Mr. FUMICH. Not necessarily.

Senator BUMPERS. Thank you, Mr. Chairman.

[The requested information follows:]

LOW BTU GASIFICATION EFFICIENCY

The conversion efficiency of the low-Btu gasification process is approximately 90 percent. That is, approximately 10 percent of the energy in coal is lost in making low-Btu gas.

Senator MATSUNAGA. As I understand it, following up on Senator Bumpers' question, the difference between underground surface and in situ coal gasification would be about $1 per million Btu in favor of underground?

Mr. FUMICH. Everything I translated to on the plus side would come out to about that final figure, but much of that is still based on assumption. We don't have all the answers. This is what we have found before in our other technologies.

We attempt to estimate cost, and a few years later we have to apologize for the cost we have mentioned. This is the reason I would rather not say for certain that this is going to be the case. We feel that's a good target based on the assumptions and information currently available. This is still pretty early in the research cycle and there are many factors yet to consider.

Senator **Matsunaga**. You have a very successful project going on now. In what State is it located?

Mr. **Fumich**. That's in Wyoming, sir, very successful. In fact, we have two successful projects, one with a steeply dipping bed. I think the technology with the steeply dipping bed could be more important than the technology with the horizontal bed. It will work better by natural forces plus the fact that steeply dipping beds in this country are very difficult to mine, because of high cost. In my opinion these will be the last coal utilized. On the other hand, any horizontal bed down to a depth of at least 1,000 feet, can be mined unless it's not worth anything at all.

Senator **Bumpers**. One other question, Mr. Chairman. The highest figure I have ever seen about the reserves of coal in this country was 1 trillion tons.

Mr. **Fumich**. Four trillion tons as far as the resource is concerned. The resource is not a reserve.

Senator **Bumpers**. I understand. I want to know if you are making a distinction between recoverable and total amount? What are the recoverable reserves in present day technology?

Mr. **Fumich**. Recoverable coal reserves are around 450 billion tons and resources are about 4 trillion tons and there's quite a difference.

Senator **Bumpers**. What is the difference?

Mr. **Fumich**. Recoverable coal is deposits of coal in which you can start a mine today and produce the coal economically. That's what you call a recoverable reserve. On the other hand, coal resources include all coal deposits, including those presently considered uneconomic to mine as well as those which are economic or recoverable.

Some of it can be way down deep where you know you can't mine today. Much of it is in the West, for instance. One of the problems we have in mining in the West is trying to mine very thick under ground coal seams. Some of these seams are 100, 200 feet thick. Presently, there is no way you can mine that coal underground without losing a lot of it. one of the things we have in our mining research program is experimental technology testing to see if we can recover most of that seam.

You have just the opposite problem in the East. In the East, we have very many thin seams but they can't be mined economically. Here we try to develop technology that can in fact mine economically the thin seams of the East. Thin seams in the East and thick seams in the West, these are our problems.

Senator **Bumpers**. Those thick seams out West——

Mr. **Fumich**. We have commercial mines today in operation, one of them in Kentucky, over 1,000 feet deep. That's a pretty thin seam, in fact, but it is also very high quality coal, and that's the reason they can do that. On the other hand, there are few underground mines in thick seams in the West—we have a mining project in a 25-foot seam where we plan to test a multilevel type of mining. This is a new technology and we're not sure how it will work. These would be resources; they're not really reserves.

Senator **Matsunaga.** Thank you very much, Mr. Secretary.

Mr. **Fumich.** Thank you all very much.

Senator **Matsunaga.** Once again, we will submit written questions.

Mr. **Fumich.** We will make sure you get the information you requested.

Senator **Matsunaga.** Our next witness is the Assistant Secretary for Environment from the Department of Energy, Mrs. Ruth Clusen.

Mrs. Clusen, we appreciate your presence here and we would be delighted to hear from you. I notice you have a prepared statement. It is quite lengthy. We would appreciate your summarizing and touching on the highlights, especially in those areas which need to be called to our special attention and then submitting yourself to questioning.

Your statement will appear in the record.

STATEMENT OF RUTH CLUSEN, ASSISTANT SECRETARY FOR ENVIRONMENT, DEPARTMENT OF ENERGY

Mrs. **Clusen.** Thank you, Mr. Chairman, I appreciate the opportunity to appear before the committee again. I will be glad to summarize rather quickly our budgetary request, particularly as it relates to some of the subjects you have been discussing here today.

In summary, I should point out that our overall budget request is for $309.6 million. This is an increase from fiscal year 1980 of $32.5 million, some 11 percent; $30.8 million of this increase is for operating expenses.

You will note from our statement that we have three primary budget categories, one which deals with overview and assessment, another biological and environmental research, and the third with life sciences research and nuclear medicine applications.

By far, the largest portion of our budget is in biological and environmental research. That's the part we look to for answers to the hard questions that permit us to go forward with current energy technology and some of the new, more exotic ones.

I thought I might dwell on what we are doing in the biological and environmental research field since the most significant budgetary increases are there. Although I know you have before you some charts that show this by scientific discipline, it might be more effective as far as you are concerned for me to talk about how the money is spent regarding technologies because you have been addressing some of the questions today.

Obviously, with the increasing interest in fossil fuels and the whole field of fossil technology, the largest part of our request will be found there. We are requesting an increase of some $12.9 million in fossil research. This is an attempt for us to come to grips with the environmental, health and safety issues, particularly in those technologies that have some promise of commercialization in the near to midterm, as well as obtaining some required information on other technologies.

Many of the questions you have been discussing with Assistant Secretary Fumich about coal combustion, coal conversion, synthetic fuels, oil shale, represent some environmental and health hazards that we need to address very seriously through research. Indeed, we are already doing so but we hope to step up our efforts.

I would like to emphasize that our priorities, as far as our budget is concerned, whether they are in research or in policy and environmental analysis, relate very closely to the priorities of the Department of Energy.

We are also spending an increased amount of money in carbon dioxide research. I note that earlier today in your opening statement, you made reference to the problems of carbon dioxide research and acid rain. If you break down what we are doing in the fossil energy field, you would find that we are, in fact, hoping to increase our research in this field by some $5.1 million.

This, of course, is because of the accelerated interest in the use of coal, in synthetic fuels, where we really need to get some answers. We have a strong program at this point in carbon dioxide research. It is part of a national plan, the central problem to which we must find an answer is how climate will respond to increased CO_2.

We hope, for instance, in fiscal year 1981 to begin to look at thermal and climate control and their relation to CO_2

In the case of acid rain, we have a relatively small program underway, something like $800,000. We are looking at it from two angles, long range transport by tracking some emissions as they make their way across the country. In addition to that, we are looking at the properties of acid rain. In fact, an interagency committee has been established, on acid rain at the request of the President. I am the DOE representative on that committee. It is just beginning to look into how it should divide up its duties and its research responsibilities in regard to acid rain. These are questions that we really cannot delay looking at any longer.

The third category in our budget is called life sciences and nuclear medicine. In this, we are requesting an increase of $6.4 million. This takes a little explanation in that life sciences primarily is basic research which undergirds the applied research that we do. It looks at cell changes and at very basic life forms.

Out of this program in the past have come some of the breakthroughs that have enabled us to do some of the work we are now doing.

Nuclear medicine application is a field in which we are requesting a $2.4 million increase. This field uses diagnostic procedures related to nuclear medicine and some noninvasive techniques.

I could go into any one of those fields in any detail that you wish. But I think it would be best, because of time, that I stop and let you address your questions to me.

[The prepared statement of Mrs. Clusen follows.]

STATEMENT OF RUTH C. CLUSEN
ASSISTANT SECRETARY FOR ENVIRONMENT
DEPARTMENT OF ENERGY
FY 1981 AUTHORIZATION HEARINGS

Mr. Chairman, Members of the Subcommittee:

Today, I am pleased to present to this Subcommittee the Department of Energy's Office of Environment budget request for FY 1981. However, before presenting the budget request, I would like to discuss the role of the Office of Environment within the Department.

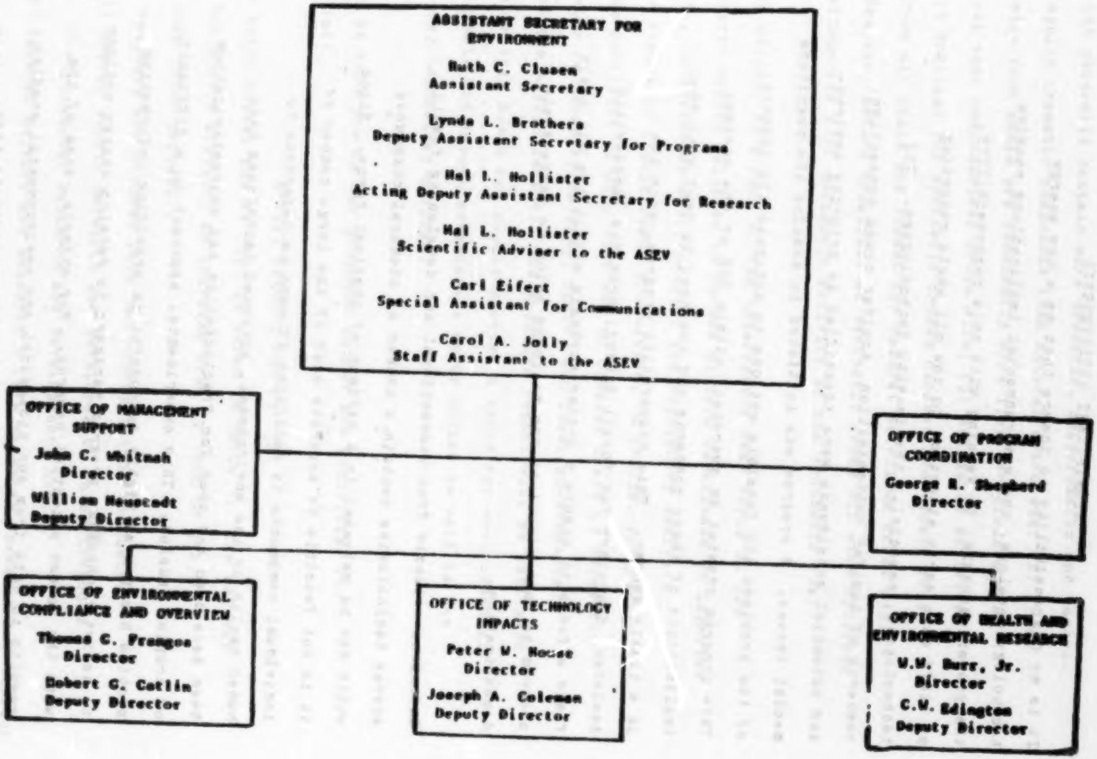
ROLE OF THE OFFICE OF ENVIRONMENT

As Assistant Secretary for Environment, it is my role to ensure that the balancing of energy and environmental objectives receive the highest priority within the Department. Thus, it is my responsibility to develop a comprehensive program of research and development on the environmental, health, and safety effects of energy technologies and to be the environmental conscience of the Department. I am committed to maintaining a strong environmental voice within the Department and to carrying out the DOE Organization Act's (P.L. 95-91) mandate that the Department assure the "incorporation of national environmental protection goals in the formulation and implementation of energy programs and ... advance the goals of restoring, protecting, and enhancing environmental quality, and assuring public health and safety." I am committed to seeing that the environmental, health and safety (EH&S) factors are accorded the same emphasis as technical and economic considerations in energy supply development and that they are integrated into Departmental decision-making from the earliest phases of energy supply development through commercialization.

To implement this commitment, the Office of Environment utilizes three line programs and two staff functions. (An organization chart for my office follows.) The Offices and their functions are:

- Office of Technology Impacts: analyzes energy and environmental health and safety issues and policies to determine their potential impact on Departmental activities and to determine the impacts of energy development on the environment.
- Office of Health and Environmental Research: plans, manages, and assesses results of research on the environmental, health, and safety effects of energy technology.
- Office of Environmental Compliance and Overview: ensures DOE compliance with environmental, health, and safety's regulations including the National Environmental Policy Act (NEPA) and those established by other Federal, state and local organizations; and also conducts an environmental control research program.
- Office of Program Coordination: coordinates planning and communications between the Office of Environment and other Departmental offices, as well as the international, intergovernmental, public, and private sectors; and the
- Office of Management Support: manages fiscal and administrative support duties for the Office of Environment.

Before we turn to the FY 1981 programs, I would like to briefly mention several significant achievements of the Office of Environment during the past year.


ASSISTANT SECRETARY FOR ENVIRONMENT
Ruth C. Clusen
Assistant Secretary
Lynda L. Brothers
Deputy Assistant Secretary for Programs
Hal L. Hollister
Acting Deputy Assistant Secretary for Research
Hal L. Hollister
Scientific Adviser to the ASEV
Carl Eifert
Special Assistant for Communications
Carol A. Jolly
Staff Assistant to the ASEV
OFFICE OF MANAGEMENT SUPPORT
John C. Whitnah
Director
William Neustadt
Deputy Director
OFFICE OF PROGRAM COORDINATION
George R. Shepherd
Director
OFFICE OF ENVIRONMENTAL COMPLIANCE AND OVERVIEW
Thomas C. Frangos
Director
Robert G. Catlin
Deputy Director
OFFICE OF TECHNOLOGY IMPACTS
Peter W. House
Director
Joseph A. Coleman
Deputy Director
OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH
W.W. Burr, Jr.
Director
C.W. Edington
Deputy Director

SIGNIFICANT ACHIEVEMENTS

It is my responsibility to insure that as a new energy technology develops, the environmental implications receive the proper emphasis. In keeping with this responsibility, my staff gave early attention to the oil shale retorting technologies, especially the in-situ technologies. The concerns of aquifer contamination, aquifer cross connection, and potential subsidence were identified as priority environmental issues. A program was initiated to examine the magnitude of the problems and feasible options to mitigate the impacts. This program created an awareness within DOE of the serious implications of these concerns and the need to deal with them in a timely manner. This cooperative program, with the Assistant Secretary for Fossil Energy, provides large-scale field efforts to ensure a proper emphasis within the oil shale program so that solutions can be found prior to large-scale demonstration.

Emissions released from conventional and developing fossil energy technologies contain a number of chemical compounds which may be released in a variety of physical forms. Since it is not feasible to separate each of the large number of individual compounds to determine if each is hazardous to human health or the environment, advanced techniques have been developed and used for fractionation and characterization of complex samples. This experimental approach to a difficult problem has proved highly successful in providing information to assist technology program managers to develop energy options with the lowest potential hazards. For example, some of the results to date from our biological and environmental studies in support of the synthetic fuels program indicate that: (1) syncrudes are not vastly different from natural petroleum on the basis of weight distribution of gross chemical classes, but generally contain more aromatic, polyaromatic and heterocyclic aromatic compounds than natural petroleum; (2) crude oils from shale are chemically more like petroleum crude oil than coal-derived crude oils; (3) mutagenic activity is greatest for synthetic crudes derived from coal, less from oil shale and lowest for natural petroleum crude oil. However, severe treatment of synthetic crude oil with hydrogen eliminates most mutagenic activity of the synthetic fuel.

My Office, as a part of the Interagency Task Force on new energy supply policies to reduce midterm dependence on imported oil, initiated an environmental and regulatory analysis of synthetic liquid fuels production. A preliminary report was published in July 1979 and an updated draft is currently being reviewed by Federal, State, and local governments and the public sector. The expanded report will be published later this month and should provide a basis for environmental analysis and impact assessments by my Office as well as the energy technology offices.

Let me turn now to our proposed budget and activities for FY 1981.

BUDGET REQUEST FOR FY 1981

Our total budget for FY 1981 is shown in Table 1. The request is for $309.6 million, an increase from FY 1980 of $32.5 million (11.7 percent).

Our requests are divided into two appropriation accounts:

1) Energy supply Research and Development, which includes Environmental Research and Development, and,
2) General Science and Research - Life Sciences Research and Nuclear Medicine Applications.

TABLE 1
DEPARTMENT OF ENERGY
OFFICE OF ENVIRONMENT
FY 1981 Budget Request (Budget Authority)
(Dollars in Millions)

	FY 1980	FY 1981	Change
Overview and Assessment	$ 56.4	$ 62.8	$ + 6.4
Biological and Environmental Research	168.9	187.1	+18.2
Life Sciences Research and Nuclear Medicine Applications	42.2	48.6	+ 6.4
Program Direction	9.6	11.1	+ 1.5
Total EV Program	$277.1	$309.6*	$ +32.5

* The $309.6 million includes: $286.6 million operating expense; $16.6 million capital equipment; and $6.4 million construction.

CONDUCT OF RESEARCH

A substantial portion of the research is performed at DOE's multi-program and dedicated program laboratories. The multi-program laboratories are:

1. Argonne National Laboratory(ANL)
2. Brookhaven National Laboratory(BNL)
3. Lawrence Berkeley Laboratory(LBL)
4. Lawrence Livermore Laboratory(LLL)
5. Los Alamos Scientific Laboratory(LASL)
6. Oak Ridge National Laboratory(ORNL)
7. Pacific Northwest Laboratory(PNL)

A sample of the dedicated program laboratories includes:

1. Ames Laboratory(AMES)
2. Bartlesville Energy Technology Center(BETC)
3. Environmental Measurements Laboratory(EML)
4. Idaho National Engineering Laboratory(INEL)
5. Inhalation Toxicology Research Institute(ITRI)
6. Mound Facility(MOUND)
7. Oak Ridge Associated Universities(ORAU)
8. Sandia Laboratory(SANDIA)
9. Savannah River Laboratory(SRL)
10. University of California at Los Angeles(UCLA)

Table 2 indicates program activities which are being emphasied in our FY 1981 budget requests.

TABLE 2

Department of Energy
FY 1981 budget to Congress
Assistant Secretary for Environment
Summary of Major Changes
(B/A in millions)

	FY 1980	FY 1981	Changes
Overview and Assessment......	$ 56.4	$ 62.8	$+ 6.4
- Expand environmental control evaluations of fossil technologies.			
- conduct radiological surveys and evaluations of facilities and land contaminated by nuclear operations.			
- expand NEPA support and safety in DOE operations.			
Biological and Environmental Research	$168.9	$187.1	$+18.2
- Research on health and environmental effects of synthetic fuel production and use.			
- expand research to determine potential global effects of increased levels of carbon dioxide.			
- research on the late biological effects in humans following low level exposure to radiation.			
- expand health and environmental risk analysis of energy technologies.			
Life Sciences Research and Nuclear Medicine Applications.......	$ 42.2	$ 48.6	$+ 6.4
- Expand fundamental research to support understanding effects of pollutants on living systems.			
- develop beneficial applicators of radiation and nuclear techniques for diagonosis and treatment of human diseases.			

The next set of tables (Tables 3 through 11) presents additional detail on specific program activities for FY 1981. In addition to the funding, the major focus for each activity is discussed.

OVERVIEW AND ASSESSMENT

Table 3 provides more detailed information to support our budget request for Overview and Assessment.

The Overview and Assessment portion of the environmental research and development activity is aimed at assuring that adequate emphasis is placed on environmental, health, and safety considerations in the formulation and implementation of energy technology decisions, plans, and programs.

TABLE 3

Office of Environment - Overview and Assessment

FY 1981 Budget Request (Budget Authority)

(Dollars in Millions)

	FY 1980	FY 1981	Change
Overview Management	$ 5.8	$ 6.6	$ +0.8
Technology Impacts	20.0	20.8	+0.8
Environmental and Safety Engineering	18.8	22.2	+3.4
Operational and Environmental Safety	9.9	11.2	+1.3
Operating Expenses	54.5	60.8	+6.3
Capital Equipment	1.9	2.0	+0.1
Total	$ 56.4	$ 62.8	$ +6.4

Overview Management

The Overview Management program includes an expansion of support to the management and implementation of the activities to assure compliance with the National Environmental Policy Act (NEPA) and other environmental legislation. Also included are activities to: (a) assure maintenance of the Federal Inventory of Energy-related Environment and Safety Research and Development; (b) provide funding for the Environmental Protection Agency's (EPA) annual evaluation of the adequacy of attention to the environmental consequences of non-nuclear energy technologies (as required in the Federal Non-Nuclear Energy R&D Act of 1974); and (c) provide Office-wide information systems support.

In FY 1980, some 240 independent reviews will be conducted to determine the need for Environmental Assessments (EAs) and Environmental Impact Statements (EISs). Approximately 125 completed EAs and EISs will be reviewed and recommendations made for approval or disapproval. In addition, approximately 15 project environmental compliance plans will be prepared and 25 EISs from other agencies with energy related activities will be reviewed and evaluated.

For FY 1981, this workload is projected to increase substantially as a result of overall national energy goals and the implementation of the Fuel Use Act. There will be approximately 310 independent reviews to determine the need for EAs and EISs, 180 completed EAs and EISs to be reviewed and recommendations for approval or disapproval to be developed, 20 project environmental compliance plans to prepare, and

30 EISs from other agencies to review and evaluate. In addition, emphasis will include revising and supplementing the DOE Environmental Compliance Guide to include State requirements, to expand the NEPA Training Program, to enhance the capabilities of the NEPA Action Tracking System, and to complete the generic environmental report guidelines for DOE bidders.

Technology Impacts

The Technology Impacts program assists the Office of Environment in advising the Department on policy decisions related to the environmental, health, and safety impacts of energy development and use. This program provides the capability to improve the understanding of the impacts of environmental policies, laws, and regulations on energy development and use, and the impacts of energy development and use on the environment.

This program consists of four major activities: policy analysis, technology assessment, environmental impacts, and regional assessment.

The policy analysis activity performs short-term analysis of proposed and existing Federal and regional environmental policies, laws, and regulations to support DOE decisionmaking. It also provides the support for participation in departmental policy formulation.

During FY 1980, analysis will be completed for air quality problems reflected in EPA's proposed industrial New Source Performance Standards, Prevention of Significant Deterioration regulations, and particulate standards governing ambient air quality. An examination of acid rain and long-range transport issues will also be initiated, with emphasis centering on water supply and other environmental issues associated with developing and siting synthetic fuels production facilities.

In FY 1981, the focus will shift to consideration of toxic effluents and solid waste issues. Analysis will be expanded to anticipate environmental concerns related to synthetic fuels production and air pollutants to determine possible impacts of proposed energy development, use, and facility siting. The regulatory impacts on DOE policies of the Clean Air Act, the Clean Water Act, the Surface Mining Control and Reclamation Act will be explored.

The technology assessment activity assesses environmental, health, and safety concerns related to energy supply and conservation technologies and is the prime link within my office with energy technology development programs.

In FY 1980, Phase II of the Comprehensive Solar Assessments will be completed. Substantial progress will also be made on the following assessments: Enhanced Oil Recovery, Gasifiers-in-Industry, Oil Shale, Uranium Solution Mining and Irradiation of Municipal Wastes, and Advanced Isotope Separation. Additional assessments will be initiated for Industrial Energy Use, Unconventional Gas Recovery, Magnetic Fusion, Transportation Conservation and Increased Coal Mining and Production. Numerous environmental planning documents will be updated.

During FY 1981, Environmental Development Plans will be revised and updated for about 30 evolving energy technologies; Environmental Readiness Documents will be generated or updated for some 22 technologies; and Project Environmental Plans will be prepared or revised for 65 to 75 major energy system projects in accordance with the requirements of the DOE Project Management System.

The environmental impacts activity assesses potential national environmental impacts of energy policies and plans and performs environmental risk, uncertainty, and economic analyses. In FY 1980, efforts will include issuing the Annual Environmental Analysis Report (AEAR) and the assessment of the Energy Information Administration second annual report to Congress.

Major tasks to be undertaken in FY 1981 will involve the preparation of an updated AEAR and impact assessments for the third National Energy Plan and the fourth EIA report to Congress. Methods for linking long-range air pollutant transport models to a regional residuals simulation model will be developed. Also estimates of costs and the economic impacts of pollution abatement will be improved and expanded.

The regional assessment activity assesses regional impacts of energy plans on land, water and air quality, human health and safety, and social and economic systems. The products of this effort include: Regional Characterization Documents (RCDs), which are a uniform collection of information on the energy-related environmental characteristics of Federal regions; and Regional Issue Identification and Assessments are used within DOE and by regional, urban and other community authorities to assist in determining impacts of energy development and use on specific regions.

During FY 1980, the second cycle of both RCDs and RIIAs will be published. In addition, comprehensive assessments of urban and community impacts of major DOE initiatives including synthetic fuels, will be started.

In FY 1981, the third generation of RIIA reports on the impacts associated with energy supply/demand forecasts will be produced for each Federal region. An update of the RCDs will be completed and an automated system will be developed to maintain and keep the data current. Also, several mitigation strategy projects tied to selected DOE demonstration projects will be initiated.

Environmental and Safety Engineering

The Environmental and Safety Engineering (E&SE) program provides my Office with the information required to make independent judgments on the environmental control component of DOE's energy programs and policies. This program is an essential aspect for developing balanced positions relative to environmental acceptability and energy supply development.

The activities within this program are directed at all energy supply developments with emphasis on fossil fuels. This is typified by the joint effort in FY 1980 between my Office and the Office of Fossil Energy on the Gasifiers-in-Industry program (ORNL). Specifically, our contributions include identification of required environmental control data and support for the collection and evaluation of the data. In FY 1981, E&SE activities will be directed at additional high priority demonstration plants including SRC and H-Coal liquefaction, (PNL, Pittsburg Energy Technology Center (PETC))

(ORNL, PETC). The need to establish acceptability of environmental controls for these technologies, is especially important in view of regulations developing in a time frame paralleling the development of the technology itself; for example, solid waste regulations under the Resource Conservation and Recovery Act and stringent discharge regulations under the Toxic Substances Control Act.

Additional FY 1981 focus in the fossil area will be directed at industrial coal applications (primary activity at ANL, Mittlehauser Corp.). In contrast to utility coal applications, assessment of industrial coal use must consider the environmental control implications of using coal in small-scale facilities where sophisticated control options are generally not economically available. Detailed evaluations will be made of the economic, engineering, and environmental trade-offs associated with the various industrial coal utilization options. The options to be considered will include conventional combustion with stack gas cleaning, fluidized bed combustion, combustion of coal/oil mixtures, advanced power systems, and conversion of coal to a premium clean burning gas or liquid fuel.

As a result of evaluations of environmental control options, we have been able in some cases to establish the feasibility of potentially enhanced environmental control options meriting interest and additional research by energy supply developers. Examples of these include an impregnated sulfur scavenger in coal which may be especially promising for industrial gasifier application (Battelle/Columbus), a cost-effective dilute hydrocarbon emission control option for Lurgi gasification to avoid the need for combustion with premium methane as proposed in an early draft EPA background document (ORNL), and an improved option for fine particulate control (State

University of N.Y.). Additional coal-related issues that we will address in FY 1981 are those associated with in-situ coal gasification (LLL) and coal extraction and preparation (LASL, ANL, Bitimus Coal Research).

Liquefied gaseous fuels such as liquefied natural gas (LNG) and liquefied petroleum gas (LPG) can represent an important fraction of the Nation's fossil energy resource. Generally unfavorable public perception of the hazards in their use must be addressed. Consequently, there is an urgent need to provide additional technical information relating to safety and environmental control issues for the handling, storing, transporting and utilizing of liquefied gaseous fuels (LGF). FY 1981 activities will include conducting 40 cubic meter LNG spill tests designed to enhance our ability to predict the behavior of large-scale spills (LLL). This is especially important because of the inability to predict the fate of a realistic size spill, perhaps of 10,000 cubic meters, based on existing data from small experimental spills of up to 10 cubic meters. Depending on the results of data analysis, preliminary site preparation for larger spill tests may be initiated.

In the areas of solar, geothermal, and conservation, FY 1981 efforts will include: (a) acquiring and evaluating field data relative to the environmental acceptability of waste disposal practices from small-scale gasohol units; (b) assessing the control implications for the effective management of hydrogen sulfide emission from operations in the Geysers region (LLL); and (c) determining environmentally acceptable building standards relating to improved isulation and ventilation guidelines (SANDIA).

During FY 1981, control evaluations for fission and fusion reactor systems will build on prior accomplishments with new emphasis on the identification of areas where laboratory and field control data should be independently acquired (PNL). To continue in FY 1981 is the program to evaluate the environmental control aspects, including control options and costs, of high priority DOE nuclear waste management programs (LASL). Special emphasis will be placed on evaluation of the adequacy of planned and the identification of alternative controls for systems including subsurface and seabed disposal and options for disposal of low level wastes.

As a part of DOE's program to clean up sites and facilities contaminated by past nuclear operations conducted for the Government, my Office is responsible for: (a) independently conducting radiological surveys to determine the nature and extent of contamination at these sites (ORNL, ANL, Mound Facility, (b) providing notification of the need and potential magnitude of remedial action, and (c) independently evaluating and concurring in plans and NEPA documents prepared for remedial action operations. In FY 1981, further radiological surveys will be conducted during and after remedial actions operations to provide documented certification that cleanup is in compliance with applicable criteria and specifications.

Initial negotiations were conducted in FY 1979 and FY 1980 with representatives of some of the affected States to establish cooperative agreements required by P.L. 95-604, the Uranium Mill Tailings Radiation Control Act of 1978. In FY 1981, special emphasis will be placed on expansion of the radon monitoring program to cover additional mill tailings sites (Mound Facility) and to determine and designate properties in their vicinity as potential candidates for remedial action.

Candidate generic and site-specific remedial action techniques will be identified and evaluated for environmental adequacy, and the most promising alternatives will be recommended for further development.

Operational and Environmental Safety

The Operational and Environmental Safety program assures that the operations and installations of the Department and its contractors comply with DOE and other applicable Federal, State and local environmental, safety and health policies, standards and regulations. We ensure that all DOE-controlled activities are conducted in a manner that will minimize risks to the safety and health of workers and the public and provide for protection of the environment.

Office of Environment staff responded at Three Mile Island and the experience gained there reinforced our efforts in FY 1980 to assure that DOE radiological emergency plans were in effect at all DOE sites. In FY 1981, additional funds will be needed to improve the DOE ability to render emergency assistance to radiological emergency requests. In an effort to preclude emergency situations at DOE facilities, EH&S appraisals of the Department's operations are conducted on a continuous basis. These appraisals not only provide management with timely and reliable information, they act as the mechanism for assuring compliance with applicable requirements affecting Federal facilities and operations. Additionally, these appraisals uncover needs for applied research in occupational safety, such as an ongoing effort for definition of potential health and industrial hygiene problems associated with workers involved in experimental and demonstration plants (e.g., coal liquefaction, synthetic fuels) of the various energy technologies. This effort will provide in FY 1981 baseline data for establishing industrial hygiene guidelines for DOE research and development operations involved with substances heretofore unknown or unused in large quantities in industrial, laboratory, or commercial applications.

Developing operational and environmental safety policies for DOE operations will be highlighted in FY 1981 by formulation of guidelines for procurement officials and DOE Source Evaluation Boards to estimate knowledgeably the cost of DOE and other Federal, State and local EH&S requirements. In FY 1980, all DOE technology programs have been implementing the safety analysis and review policy initiated by my Office. Assurance that these analyses are independently reviewed will be emphasized in FY 1981. DOE occupational medicine recordkeeping policies are being standardized through the development of a system which will have the capability to correlate DOE and DOE contractor workers' health status with occupational hazards data. With preliminary design of the systems completed in FY 1980, implementation on a pilot basis will be achieved in FY 1981.

Capital Equipment

Equipment funds in the amount of $2.04 million are being requested in FY 1981 for the Overview and Assessment Program. These requirements are in support of: (1) the Environmental and Safety Engineering program for test equipment and instrumentation for analyses of environmental controls, experiments for various energy technologies, and radiological surveys and evaluations of former MED/AEC and inactive mill tailings sites; and (2) the Operational and Environmental Safety program for additional and replacement equipment for technical assistance in radiological emergencies, acquisition and analysis of optical and infrared data, and support of research in operational safety and fire protection.

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

Table 4 provides information about the program to support our budget request for Biological and Environmental Research (BER).

TABLE 4

Office of Environment - Biological and Environmental Research

FY 1981 Budget Request (Budget Authority)

(Dollars in Millions)

	FY 1980	FY 1981	Change
Human Health Studies	$ 27.1	$ 30.0	$ +2.9
Health Effects in Biological Systems	47.1	50.6	+3.5
Environmental Studies	35.2	36.3	+1.1
Physical and Technological Studies	31.2	33.6	+2.4
Carbon Dioxide and Climate Effects Research	9.0	13.9	+4.9
Health and Environmental Risk Analysis	1.4	4.6	+3.2
Operating Expenses	151.0	169.0	+18.0
Capital Equipment	11.9	11.7	- 0.2
Construction	6.0	6.4	+ 0.4
Total Biological & Environmental Research	$168.9	$187.1	$+18.2

A major thrust of the Department is to ensure that energy supply technologies are developed and commercialized with minimal impact on human health and the environment. To achieve this, it is essential that both generic and process-specific information be available for evaluation of the potential health and environmental impacts of high priority technology processes and conservation options. The Biological and Environmental Research program is the only program within DOE which plans, funds and administers a comprehensive research effort to obtain this information.

My Office works closely with the technology program offices to identify environmental, health, and safety issues, research requirements, and program responsibility for resolving the issues. This information has been documented in Environmental Development Plans (EDPs) for technology programs and in process-specific Project Environmental Plans (PEPs). These documents, therefore, provide the basis for BER program priorities, planning and implementation.

The increase in operating expenses will permit expansion in research on and assessment of the potential global effects of increased levels of carbon dioxide in the atmosphere (+$4.9 million).

In addition, increased support will be provided for health and environmental risk analysis (+$3.2 million); research on human health effects of pollutants (+$2.9 million); biological effects in experimental animal systems (+$3.5 million); ecological research (+$1.1 million); and pollutant characterization, measurement and monitoring (+$2.4 million).

Although the Biological and Environmental Research program is structured and budgeted in a disciplinary mode, our research activities are directed at resolving high-priority energy development environmental, health and safety issues. Emphasis is given to those technologies which have promise of commercialization in the near to mid term, as well as obtaining required information on long-term energy technologies. Funding levels for research by technology are presented in Table 5 and the research activities in support of these technologies are summarized in the discussion which follows.

TABLE 5

Biological and Environmental Research

Summary by Technology

FY 1981 Budget Request (Budget Authority)

(Operating Expenses-Dollars in Millions)

	FY 1980	FY 1981	Change
Fossil	$ 51.2	$ 64.1	$+12.9
Inexhaustible	12.3	14.4	+ 2.1
Nuclear Fission	62.8	65.4	+ 2.6
Multi-technology	24.7	25.1	+ 0.4
Total Biological and Environmental Research	$151.0	$169.0	$+18.0

Fossil Energy

Because of the importance of fossil fuels in the Nation's energy future and the fact that much information is needed on the health and environmental effects associated with the use of fossil fuels as an energy source, high priority is placed on research in support of these technology developments. The FY 1981 budget requests $64.1 million for fossil energy-related health and environmental research, which is 37.9 percent of the BER operating budget request. The funding levels for research in support of the various fossil energy program activities are shown in Table 6.

TABLE 6

Summary of Research by Fossil Energy Technology

FY 1981 Budget Request (Budget Authority)

(Operating Expense-Dollars in Millions)

	FY 1980	FY 1981	Change
Coal Extraction	$ 2.5	$ 2.7	$+ 0.2
Coal Combustion	14.1	16.1	+ 2.0
Coal Liquefaction	16.3	19.2	+ 2.9
Coal Gasification	5.1	6.4	+ 1.3
Oil and Gas	1.8	2.2	+ 0.4
Oil Shale	5.2	6.2	+ 1.0
Carbon Dioxide Research*	6.2	11.3	+ 5.1
TOTAL	$51.2	$64.1	$+12.9

* Excludes climate research.

Synthetic Fuels

Determination of the toxicity, mutagenicity, carcinogenicity or other biological effects of individual environmental pollutants is not an easy task. The tests required are long term in nature, expensive and require a large number of animals to obtain statistically significant results.

Integrated biological and environmental research activities are conducted in close cooperation with technology program offices and contractors at the SRC I and SRC II pilot plants (PNL), Hygas Pilot Plant (ANL), the low Btu gasifiers-in-industry demonstration plant (ORNL), and the _in situ_ coal gasification test project (LLL) at Hoe Creek, Wyoming. In addition, integrated research plans have been or are being developed for research to be conducted at the H-Coal (ORNL) and Exxon Donor Solvent liquefaction pilot plants, the planned SRC I and II demonstration plants, a second low Btu gasifier and other proposed coal conversion technology developments.

Work has been conducted on samples from the recently closed Paraho oil shale retort facility. No other surface retorting operations exist at this time; therefore, shale research is primarily confined to activities associated with current modified _in situ_ shale retort testing (Colorado State University, LASL, PNL).

Integrated health and environmental research will continue to increase as new pilot and demonstration plants are completed and become operational. In addition, considerable effort will be devoted to obtaining quantitative information on the early and late biological effects of specific chemicals or classes of chemicals which have been identified as being potentially hazardous to human health and the environment.

Coal Combustion

Major health and environmental concerns are associated with the direct combustion of coal, and increased combustion of coal will increase these concerns. The concerns include: (1) the potential global impact of increased levels of carbon dioxide in the atmosphere; (2) the chemical conversion, behavior and fate of pollutants released to the environment and transported over long distances; (3) the environmental effects, including the effects of acid rain, of such pollutants which are released as gaseous, liquid or solid wastes to the environment; and (4) the health effects of toxic and noxious gases, trace elements, particulate materials, and polycyclic aromatic hydrocarbons.

I plan to expand our research at the DOE laboratories and energy technology centers to determine the magnitude of the effects associated with combustion of coal in conventional combustion facilities as well as in advanced coal combustion processes. This research will also be of value as a basis for establishing the need for control technology development.

Coal Extraction

Increased use of coal will require increased underground and surface mining of coal and the need to ensure that proper procedures are taken to protect the environment. After consideration of national needs and the role of other Federal agencies, we have prepared a comprehensive research plan for environmental activities, which focuses on those problems associated with land reclamation needs following surface mining.

During the past year, a cooperative study at ANL, with several universities, and with local and state organizations in the mid-west has been completed. Methodologies were developed which will result in savings of approximately $850 million in reclaiming abandoned strip mines. Successful reclamation of such lands, however, will require that investigations are conducted over long periods of time.

During FY 1981, EV-funded research will be initiated by the University of Tennessee to evaluate the environmental consequences and reclamation needs following use of alternative mining techniques on steep slopes. Work will continue on evaluation of the economic and ecological costs and/or benefits of top soil storage and reapplication of top soil at a Northern Great Plains mine site. A final report will be issued in FY 1981.

Oil and Gas

In support of oil and gas technologies, instrumentation and methods are being developed for detection and measurement of the effects of toxic substances in samples of refinery workers' blood, semen, and serum (LLL). In addition, an epidemiological study of mortality and morbidity in petroleum refinery workers and individuals in the surrounding community of Contra Costa County, California, will be conducted (LBL). In FY 1981, a new research effort will be initiated to determine the potential health effects of organic chemicals, surfactants, and polymers used in enhanced oil recovery processes(PNL, LASL).

In FY 1981, final reports will be completed on the analysis of chemical components of drilling muds and their toxicity to commerical shellfish.

In addition, a study by the National Academy of Sciences which is considering the future role of DOE's environmental program in Alaska in relation to other Federal programs will be completed and will provide a guide for further development of our ecological research effort in Alaska.

Oil Shale

An oil shale management plan has been developed jointly by my Office and the Fossil Energy Office which defines the problems at issue and the responsibility for their resolution. We are responsible for research to develop the health and environmental effects associated with retort abandonment; operational health and safety guidelines; solid waste disposal; waste water treatment systems and emission control strategies as they relate to the atmospheric transport of emissions from retort facilities.

Investigations will be conducted to identify the potentially soluble components in underground retorts, migration velocities in ground water strata and toxicological properties of these substances. Field work will be conducted at operating sites managed by Occidental Oil Shale, Inc., and the Rio Blanco Oil Shale Project and coordinated with the U.S. Geological Survey. (PNL, LBL, LASL, University of Colorado, and Colorado State University).

In FY 1981, it is expected that the degree of potency of materials subject to mobilization by ground water, and of others present in the workers environment will have been identified, and preliminary estimates of risk will have been made.

Carbon Dioxide Research

Research programs are continuing to learn more about the potential effects of the carbon dioxide released from all forms of fossil fuel combustion. The Office of Environment will supplement ongoing research and initiate activities in important areas not currently under investigation by the U.S. or foreign research establishments.

Investigations of the relationship between past global carbon dioxide levels and past climatic conditions will be conducted in an attempt to use such relationships as predictors of the future and for the verification of climate models. Precise historical carbon dioxide records will be correlated with recent climate records as well as with paleclimatic information to determine whether such relationships exist. To accomplish this, in FY 1981, use will be made of a historical record of carbon dioxide taken from spectrographic analyses of solar radiation measured at the Smithsonian Institution since about 1900. In addition, research will be conducted to estimate much earlier carbon dioxide concentrations by measuring the carbon dioxide trapped in dated glacial ice.

The significant questions of the role of the oceans as a sink for carbon dioxide will be addressed under a joint program with the National Science Foundation (NSF). Information on ocean circulations will be obtained to determine the mixing and transport of the large oceanic water masses that will ultimately remove much of the excess carbon dioxide from the atmosphere. Also in FY 1981, research will begin for estimating the size and significance of the shallow water carbonates as a "quick acting" sink.

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The central question related to carbon dioxide is how climate will respond to an increase in atmospheric carbon dioxide concentrations. Answers are being sought through the development and use of simple, as well as more complex, highly detailed mathematical representations of the atmosphere in which circulation, moisture and thermal fields of the atmosphere are modeled.

In FY 1981, measurement and modeling research will begin to address thermal control exercised by the world's oceans.

Our research activities will be coordinated with other related programs in the Federal government by the Interagency Committee on Carbon Dioxide Research. This Committee, permanently chaired by the DOE, was created by the National Climate Program Office and will function under the auspices of that Office.

In FY 1981, expanded funds will be provided to the National Oceanic and Atmospheric Administration (NOAA) to further develop and refine their program in global carbon cycle modeling and to expand a joint program with NOAA for carbon dioxide measurements made by their Program on Geophysical Monitoring for Climatic Change. This will involve increases in the number of global measurement stations and the acquisition of new systems to perform these measurements more economically.

Inexhaustibles

Although commercialization of most inexhaustible energy technologies will not take place until the year 2000 or later, there are health and environmental issues which must be resolved in the near-to-mid-term to guide decisions that will need to be made about their environmental acceptability and place in our energy future. We, therefore, have initiated research to provide data for environmental input to support technology program and departmental decisions on development and commercialization of these technologies. The FY 1981 budget request for research in support of these technology developments is shown in Table 7.

Table 7

Summary of Research by Inexhaustible Energy Technologies

FY 1981 Budget Request (Budget Authority)

(Operating Expense-Dollars in Millions)

	FY 1980	FY 1981	Change
Solar	$ 1.8	$ 2.7	$+ 0.9
Geothermal	1.8	2.0	+ 0.2
Conservation	6.0	6.9	+ 0.9
Fusion	2.7	2.8	+ 0.1
TOTAL	$12.3	$14.4	$+ 2.1

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Solar

Research is being supported to address the environmental, health, and safety concerns associated with solar heating (ITRI), photovoltaic (BNL), solar thermal(UCLA), ocean thermal (University of Puerto Rico) and satellite power solar systems.

In FY 1981, short-term toxicological testing of working fluids will continue as new commercial products are identified (ITRI).

In FY 1981, construction of the heliostat (solar collector) field at Barstow should be completed. This will permit start-up of micro-meteorological work within the heliostat array to measure direct, diffuse, and net radiation; heat fluxes; air, surface, and oil temperatures; and wind characteristics (UCLA).

Studies are also in progress to define the effects of high-energy, densely ionizing radiation produced in biological systems (LBL). Once the biological effectiveness relative to the more familiar forms of ionizing radiation is defined, the estimation of radiation health risks associated with solar satellite power systems will be significantly facilitated.

Geothermal

Of the three general geothermal subtechnologies: steam or very-high-temperature water for production of electricity; moderate-temperature water for direct application to heating or processing; and very high-pressure, methane-containing (geopressured) sources, only the third is presently limited by technological problems. Development of the first two sources of geothermal energy can proceed rapidly using refinements of technology currently available.

A comprehensive environmental base-line study of the Imperial Valley, California, region has been completed (LLL). An integrated study of transport, fate and environmental effects of gaseous and liquid effluents is in progress at the Geysers, California site where geothermal energy is presently used for production of electricity (LLL, LASL, PNL, Atmospheric Turbulence Diffusion Laboratory (ATDL)). Because of the nature of the terrain at the Geysers' site, the atmospheric studies have been coupled to a broader study of the transport and diffusion of atmospheric pollutants over complex terrain. This study will be used as a model and investigations will be completed in FY 1981. As the field research at the Geysers is phased down, an integrated health and environmental research program will be initiated in support of the liquid-dominated, hightemperature 50 Megawatt geothermal plant in New Mexico (LASL). A field study will also be initiated and completed in FY 1981 to determine the nature and behavior of cooling tower plumes in the Geysers area.

Conservation

By effecting an overall reduction in energy utilization, energy conserving technologies as a whole tend to mitigate pollution and associated environmental impacts. Nevertheless, certain unique pollutants or characteristic environmental alteratives are associated with each energy-conserving technology. Our research is directed at problems associated with some of these technologies: high voltage power lines (PNL, BNL, LASL, University of Rochester), light duty diesel engines (ITRI, BETC), alternative automotive fuels (BETC, LLL), utilization of urban waste as an energy source(Ames, University of Miami), increased insulation of buildings (ITRI, New England Deaconess Hospital), and electric storage battery development and use (ANL).

The efficient transmission of electric power is of critical importance to the success of the Nations's energy program. As line voltages have increased, concern has been expressed about the possible adverse biological effects associated with high-intensity 60-Hertz electric fields surrounding overhead transmission lines.

Research is being conducted and will continue to develop methods to measure electric fields and currents induced in tissues of animals and humans to: (a) determine effects of body conformation; (b) evaluate possible genetic effects of high intensity fields; (c) determine effects on cell replication, growth and development; and (d) study behavioral and neuro-endocrine responses of rodents exposed to external electric magnetic fields.

The large-scale production of ethanol by fermentation of biomass presents possible problems associated with the disposition of large quantitites of by-products of alcohol fermentation. In addition, possible effects of evaporative and exhaust emissions from ethanol-containing fuels on air quality and human health are ill-defined. Because of its high toxicity, methanol presents greater hazard as an automotive fuel than does ethanol. Large-scale production of methanol from coal also raises concerns regarding hazardous by-products and residues. To address these concerns, studies are in progress and additional work is planned in FY 1981 to provide information on the character and quantity of regulated and unregulated exhaust emissions. A workshop will be convened during FY 1980 to take a detailed look at possible impacts of the large-scale use of alcohol (ethanol or methanol fuels) on air quality and human health.

Urban solid waste has been handled for the most part as an undesirable by-product of our society. It has been disposed of by dumping on land or in bodies of water. Disposal has created situations which have adversely affected both humans and their environment. To mitigate these impacts and exploit the potential energy available in urban waste materials, two projects designed to convert municipal solid wastes into useful products are being investigated. The first involves an evaluation of potential health and environmental consequences of processing municipal solid wastes into a refuse derived fuel (RDF) and co-combustion of this fuel with coal in an electric generating plant. The second is being conducted in conjunction with an anaerobic RDF digestion facility and is focusing on characterization of emissions, effluents and residuals generated by the digestion plant, the interaction of these materials with the environment and the consequences of such interactions.

Emphasis is being focused on the conservation of energy by increased insulation of buildings. Among the most useful materials for this purpose are naturally occurring fibers, such as asbestos, and man-made material, such as glass fibers coated with synthetic resin binders. Epidemiological data indicate that asbestos can cause lung cancer in humans and limited data from animal studies tend to confirm this fact. Information on the toxicity of fiberglass is incomplete. Studies are in progress to determine the effects of asbestos on the lifetime carcinogenic response of rodents.

The development of more energy-efficient buildings leads to reduction in the rate of exchange between indoor and outdoor air. Data from two ongoing studies will contribute to an overall evaluation of potential health risks associated with increased pollutant levels in energy-efficient homes and provide insights into methods of controlling indoor air pollutants. Work is also in progress to identify all significant indoor air pollutants and their sources to determine the impact of energy conservation on indoor air quality and the effects of increased pollutant levels on human health.

New and improved storage batteries are being developed for application in electric and hybrid vehicles and for load-leveling purposes in the electric power industry. The production, use, recycle and disposal of storage batteries, however, poses a health hazard due to potential human exposures to a variety of toxic chemicals.

Fusion

Developments in the magnetic fusion energy program have reached a point where potential health and environmental impacts of fusion reactors must be considered. Commercial development of this energy technology will not occur until the turn of the century; therefore, research is restricted to fundamental studies related to the key concerns that can be foreseen at this time.

Near-term environmental, health and safety concerns include the biological effects of tritium gas releases, neutron activitation products, toxic substances such as beryllium and lithium used in blanket materials and magnetic fields. Experimental studies to determine the genetic, reproductive, and behavioral effects of exposure to tritium are also in progress.

Investigations are also conducted to: (a) determine the environmental transport of tritium and rates of conversion to tritiated water (HTO) in rivers, estuaries and oceans (SRL); (b) investigate the movement of tritium through soils and food chains (SRL, ORNL); (c) study (on a selective basis) the metabolism and dose distribution of specific fusion-related neutron activitation products (ORNL); (d) determine the transport of neutron activation products in aquatic and terrestrial environments (ORNL); and (e) investigate the acute and chronic toxicity of lithium and beryllium on aquatic biota (PNL).

Fission

The importance of nuclear energy in our energy future requires continued and in some cases expanded research, to resolve environmental, health, and safety issues and public concern about the effects of low level radiation. In broad perspective, these issues can all be related to an increasing need for: (1) the development of techniques for measurement of low level radiation doses to which workers or the general population may be exposed from routine operations or accidents and (2) the evaluation of the real or potential risk to human health associated with such exposures.

In FY 1981, much of the research now being devoted to the development of methods for measurement of plutonium and other transuranic radionuclides in environmental media and in the human body will be completed. Research will be directed to the application of similar techniques for measurement of radium, thorium, and uranium which will be relevant to development of other nuclear fuel cycles and radiological impact of nonnuclear energy technologies, which redistribute naturally-occurring radionuclides in the environment.

Extensive research efforts are in progress to determine the late biological effects of low level radiation exposures on experimental animals (National Laboratories, specialized EV laboratories, Universities). These data will permit a quantitative assessment of the potential carcinogenic and genetic hazards and extrapolation to risk estimates for humans.

The available possibilities for genetic studies on irradiated humans are limited; therefore, experiments with animals and cellular and molecular systems are being conducted to obtain data needed for the estimation of genetic hazards to humans. This research includes studies to define the mechanisms of damage and repair of genetic material at the molecular level in a variety of organisms and test systems, each of which is chosen for its suitability for answering specific questions related to mutagenesis and its potential consequence to human populations (National Laboratories, specialized laboratories, Universities).

This program also supports a limited number of important, highly selected epidemiological studies to provide information on the late biological effects in humans who have been exposed to radiation from external radiation sources or radioactive nuclides that have been incorporated in the body. These investigations include populations of individuals who were exposed in the work place or in the general environment as a result of direct radiation from atomic bomb detonations or fallout from bomb testing.

Four epidemiological studies are in progress which are following occupationally exposed individuals. These include an expanded study of the health and mortality of DOE contractor employees who were exposed to low levels of radiation as a result of their employment in DOE facilities (LASL, ORAU Hanford Environmental Health Foundation), at the Naval Nuclear [illegible] employees and patients who were exposed occupationally or therapeutically, respectively, many years ago to radium or thorium (ANL). In addition, an epidemiological study in Japan has been supported for over thirty years and will continue to be supported through the National Academy of Sciences to determine the late effects of radiation on the individuals exposed at Hiroshima and Nagasaki and their children.

Multitechnology

Many health and environmental issues are common to more than one technology. For example, the production of particles, their transport, fate and effects on human health and the environment represent a concern which impacts all of the fossil technologies and several solar and conservation options as well. The multitechnology activity provides an essential base of environmental information to both existing and developing technologies.

Studies encompassing pollutants common to several energy technologies includes heat and chlorine which are discharged from coal, oil and nuclear power plants, and trace metals and organic compounds which are found in many types of synthetic and natural fossil fuels. Investigation of the dispersion, fate and effects of these pollutants would be repetitious if conducted for each individual technology. However, the results of multitechnology program in generic studies can be applied to many technologies.

One thrust of our multitechnology program is to develop instruments and measurement techniques with improved sensitivity and selectivity. In particular, efforts will be made to accelerate development and use of advanced laser and resonance ionization spectroscopy systems for measurement of pollutant materials (BNL, ORNL, LBL, PNL), to improve instrumentation and techniques for use in protection of workers against exposure to particulate emissions (LASL, EML), and to develop and apply procedures for aerosol analysis by element, chemical species and morphology (LASL, EML, PNL). Some techniques for microscopic examination and chemical analysis of collected particulate matter are being established using x-ray absorption and fluoresence methods (LBL).

Research into the dispersion and fate of atmospheric pollutants is being approached in three main areas: studies of transport in complex terrain (the Atmospheric Studies in Complex Terrain Program), development of an in-field measurement capability, and development of transport models (LLL, PNL, LASL, ATDL). For integration of results from field experiments with model development, investigations on pollutant transport in complex terrain are being carried out in a mountain valley in the Geysers area of California. This research will be completed in the next two years.

Studies of species community stability under natural and disturbed conditions are providing a basis for evaluating man-induced stresses of ecosystems in areas of energy development. Progress has been made particularly in the shrub-steppe ecosystem of the Northwest, an area in which considerable energy-related activity is expected in the near future (PNL). Natural population fluctuations and cycles are being studied, particularly in desert and arid regions, allowing for better evaluation and interpretation of fluctuations observed in areas having energy-related activity (PNL, UCLA, EG&C, Idaho). A methodology has been devised using diversity, nutrient cycling, biomass production, disease sensitivity, etc. (PNL), to assess the degree of energy impact on the terrestrial environment and is being tested this year in cooperation with National Park Service, U.S. Forest Service, and EPA. The ocean is the ultimate receptor of pollutants from river discharges, onshore energy producing plants, offshore exploration and routine or accidental spills associated with transport of petroleum and other energy products. It is important, therefore, to understand the movement of water on the continental shelf, the nature of marine ecosystems, dispersion and fate of pollutants, and the pollutant effects on marine ecosystems. Since the physical, chemical and biological characteristics on the continental shelf of the oceans vary in different coastal regions, marine research in activities are organized and managed on a regional basis.

Research is underway to determine how much of the material discharged from rivers and estuaries is entering the water masses that sweep along the continental shelf, how much of the material is from other sources, and how this may be affecting the food chain (BNL, SRL, Woods Hole Oceanographic Institute, Skidaway Institute of Oceanography, North Carolina State University, University of Miami, University of Georgia). Recent results have shown that the prime source of mercury entering southeastern coastal waters is the atmosphere (i.e., from the industrialized continental United States), but concentrations of other trace metals from deep oceanic upwelling appear to far surpass those of trace metals found on the continental shelf(Skidaway Institute).

Capital Equipment

Equipment funds in the amount of $11.7 million are being requested for FY 1981. These requirements are in support of environmental and health effects research involving analytical techniques and applications requiring specialized and sophisticated equipment. The types of items required include; spectrometers, growth chambers, refrigerated centrifuges, and pulsed x-ray systems.

Construction

Construction funds in the amount of $6.4 million are being requested for FY 1981. These requirements are for: (1) biomedical laboratory addition at Lawrence Berkeley Laboratory, $1.4 million; (2) modernization of laboratories at Oak Ridge National Laboratory, $2.0 million; and (3) various general plant projects, $3.0 million.

LIFE SCIENCES RESEARCH AND NUCLEAR MEDICINE APPLICATIONS

This program includes two independent research efforts. The General Life Sciences program represents the only DOE program which conducts fundamental biological research in selected areas to undergird the more applied Biological and Environmental Research effort. The Nuclear Medicine Applications program is focused on beneficial application of radiation, radionuclides, and stable isotopes in clinical nuclear medicine for diagnosis and treatment of human diseases.

The following table (Table 8) provides a distribution of the funds requested for FY 1981 and additional details are discussed below.

TABLE 8

Life Sciences Research and Nuclear Medicine Applications

FY 1981 Budget Request (Budget Authority)

(Dollars in Millions)

	FY 1980	FY 1981	Change
General Life Sciences	$22.9	$25.7	$+ 2.8
Nuclear Medicine Applications	17.6	20.0	+ 2.4
Program Direction	0.2	-	- 0.2
Operating Expenses	40.7	45.7	+ 5.0
Capital Equipment	1.5	2.9	+ 1.4
TOTAL	$42.2	$48.6	$+ 6.4

General Life Sciences

The General Life Sciences research program provides support for long term basic research in the biological and environmental sciences, chemical physics and a sustained basic research capability in instrumentation development. The objectives of this program are to understand the basic structure, function and interrelationships of all key components of living organisms and terrestrial, fresh water and marine ecosystems; to obtain basic information on the action of energy-related pollutants on biological material; and to develop rapid, automated, high-resolution instrumentation and techniques for use in biological and environmental research. The objectives are accomplished through a coordinated program of research performed at national laboratories, universities, hospitals and specialized biomedical laboratories. This research program will specifically permit (1) determination of the structure and activity of selected important macromolecules and cell membranes, (2) understanding of the characteristics of growth and development of cells from various tissues and the mechanisms involved in regulating cell metabolism, (3) determination of the molecular basis of genetic structure, chromosome replication, the repair of genetic damage and the relationship of mutagenesis to carcinogenesis, (4) development of advanced biological instrumentation systems for research on the biological principles related to pollutant effects, (5) study of the normal organization and function of ecosystems for comparison to stress ecosystems and interpretation of physical and chemical effects produced by energy-related activities and (6) to study basic physical and chemical physics processes that govern biological and environmental response to pollutant insult.

The budget increase requested for the research program in FY 1981 will be used to expand research in cellular biology to aid in development of cell and tissue models for interpretation of biological effects produced by toxic materials (+$1.1 million), to evaluate biological mechanisms involved in removal of inhaled particulates from the lung (+$0.8 million), to expand research on structural changes in key, pollutant sensitive, biological macromolecules when complexed with toxic agents (+$0.8 million) and to support fundamental investigations on biological material (+$0.5 million using the new National Synchrotron Light Source Facility at the Brookhaven National Laboratory.

Nuclear Medicine Applications

The Nuclear Medicine Applications research and development program provides support for research on and development of new applications of radiation and radioisotopes for the diagnosis and treatment of human diseases. Promising new approaches are tested for feasibility and, if successful, the techniques and instrumentation are transferred for use in clinical medicine. Without these nuclear medicine practices, non-invasive methods for diagnosis of abnormalities and diseases of the heart, lung, liver, spleen, kidneys, central nervous system, skeleton and other organs and tissues of the human body would be impossible.

In addition to providing typical, static organ pictures, nuclear medicine techniques are being used currently for dynamic normal and abnormal organ function. The diagnostic examinations include studies of heart actions, assessments of kidney and thyroid function, early detection of transplant rejection, total blood volume and other important studies of body functions.

One of the important new developments permits the clinician to use appropriate radiopharmaceuticals, control recording of photon counts and record the heart image at the end of systole and diastole. Playback of the data through motion picture displays allows the clinician to determine whether the left and right ventricles are contracting normally.

In addition to research and development efforts using radiation and radioactive isotopes, high purity stable, non-radioactive, isotopes of carbon, oxygen and nitrogen are being produced (LASL). These stable isotopes are being used to label specific compounds for application in medical, biological, environmental and agricultural research. These labeled compounds are extremely useful in sensitive tests for disease diagnosis, for initiation and expansion of research for studies on the biological behavior in, and effects on, humans and the environment.

The increase requested for research in this program is to expand development of new nuclear medicine techniques for determination of normal and abnormal organ functions using improved tomographic detection devices at LBL (+$0.9 million) and to develop new nuclear techniques for diagnosis and treatment of human diseases at BNL, LASL, UCLA, LBL, ORAU and several Universities (+$1.5 million).

Capital Equipment

Equipment funds in the amount of $2.9 million are being requested for FY 1981 for Life Sciences and Nuclear Medicine Applications program. These requirements are for: (1) new and replacement research equipment and instrumentation such as liquid chromatographs, fluorimeters, microscopes, and scintillation probes; and (2) the proposed biological beamline at the National Synchrotron Light Source Facility (BNL) ($0.7 million).

PROGRAM DIRECTION

The following table (Table 9) provides a summary of our personnel resource budget request.

TABLE 9
DEPARTMENT OF ENERGY
Office of Environment
PROGRAM DIRECTION - SUMMARY
FY 1981 Budget Request (Budget Authority)
(Dollars in Thousands)

	FY 1980	FY 1981	Change
Environmental Research and Development			
Program Direction	$9,568 a/	$11,133	$+1,565
Life Sciences and Nuclear Medicine			
Program Direction	237	0	-237
Total Program Direction	$9,805	$11,133	$+1,328

The budget request for personnel resources provides salaries, personnel benefits, travel, and administrative support for 234 full-time permanent employees in the Office of Environment, plus 11 staff years of effort by part-time employees and consultants.

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a/ Excludes $526 thousand for pending pay raise supplemental.

These employees formulate, develop, manage and evaluate the programs carried out by the Office of Environment to meet our responsibilities for assuring that the environmental research, assessment, compliance and control issues related to current and developing energy technologies and Departmental operations are addressed effectively.

During FY 1980 and FY 1981, our personnel resources are associated with two program areas; Program Direction within the Life Sciences Research and Nuclear Medicine Applications area, and Program Direction within the Environmental Research and Development area. Because we have a small program direction staff in the Life Sciences Research and Nuclear Medicine Application Program area and because of the broad interdisciplinary relationship between this program and the Environmental Research and Development program in the Office of Environment, we plan to administratively combine the staff under environmental research and development in FY 1981. The following table (Table 10) describes the staff distribution by program in FY 1980 and FY 1981.

TABLE 10

Personnel Resources - Staff Distribution - Office of Environment Budget Request

	FY 1980	FY 1981	Change
Environmental Research and Development			
Program Direction	226	234	+ 8
Life Sciences and Nuclear Medicine Application			
Program Direction	6	0	- 6
TOTAL	232	234	+ 2

During FY 1980, the Environmental Research and Development program direction staff was increased from 220 to 226 as a result of the additional NEPA workload to support the Fuel Use Act. The FY 1981 budget request reflects an increase of two positions to support the augmented CO2 program and the program to perform the risk analysis of health and environmental effects associated with the development of synthetic fuels and other advanced fossil technologies.

The following table summarizes the program direction staffing and funding request for the Office of Environment for FY 1981.

TABLE 11

Office of Environment

Program Direction Summary

(Dollars in Thousands)

	FY 1980	FY 1981	Change
Year-end Full-time Permanent (FTP) Staff	232	234	+ 2
Year-end Other than Full-time (OTFTP) Staff	11	11	0
Staff Years of FTP Effort	210	229	+19
Staff Years of OTFTP Effort	9	11	+ 2
Salaries of FTP Personnel	$ 7,864	$ 8,947	$+1,083
Salaries of OTFTP Personnel	617	710	+ 93
Personnel Benefits	956	1,036	+ 80
Travel of Persons	368	440	+ 72
TOTAL REQUEST	$ 9,805 a/	$11,133	$+1,328

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a/ Excludes $526 thousand for pending payraise supplemental.

Table 12

OFFICE OF ENVIRONMENT

(Dollars in Thousands)

DEPARTMENTAL ADMINISTRATION

	FY 1980	FY 1981	Change
Funding	$2,788 a/	$3,011	$+223
Staffing	71	71	-

The staff resources contained in this Departmental Administration appropriation are considered separately by this subcommittee. However, this information is presented here to give you a complete account of the staffing of the Assistant Secretary for Environment. The 71 positions identified here comprise the staff of my immediate office and the staff which supports me in the coordination, implementation and overview of ASEV management and financial functions; planning and analyses functions.

In conclusion, this budget request for personnel resources has been constructed to recognize our program priorities effectively while also addressing the necessity to manage within resource limits.

Mr. Chairman, this concludes my statement of the FY 1981 Budget Request. I would be pleased to answer any questions.

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a/ excludes $11 thousand for pending payraise supplemental.

ASEV: FY 1981 Budget Request Summary

budget authority in millions

Budget Summary	FY 1980	FY 1981	Change
Overview & Assessment	$ 56.4	$ 62.8	$ + 6.4
Biological & Environmental Research	168.9	187.1	+18.2
Life Sciences Research & Nuclear Medicine Applications	42.2	48.6	+ 6.4
Program Direction	9.6	11.1	+ 1.5
Total ASEV Program	$277.1	$309.6*	$ + 32.5

*Includes Capital Equipment & Construction of $23.0 Million, an Increase of $1.7 Million

Overview & Assessment

budget authority in millions

	FY 1980	FY 1981	Change
Overview Management—NEPA	$ 5.8	$ 6.6	$ + 0.8
Technology Impacts	20.0	20.8	+ 0.8
Environmental and Safety Engineering	18.8	22.2	+ 3.4
Operational and Environmental Safety	9.9	11.2	+ 1.3
Capital Equipment	1.9	2.0	+ 0.1
			$ + 6.4

Biological & Environmental Research

budget authority in millions

by discipline	FY 1980	FY 1981	Change
Human Health Studies	$27.1	$30.0	$+2.9
Health Effects Research in Biological Systems	47.1	50.6	+3.5
Environmental Studies	35.2	36.3	+1.1
Physical and Technological Studies	31.2	33.6	+2.4
Carbon Dioxide and Climate Research	9.0	13.9	+4.9
Health and Environmental Effects Risk Analysis	1.4	4.6	+3.2
Capital Equipment	11.9	11.7	-0.2
Construction	6.0	6.4	+0.4
			$+18.2

Biological & Environmental Research

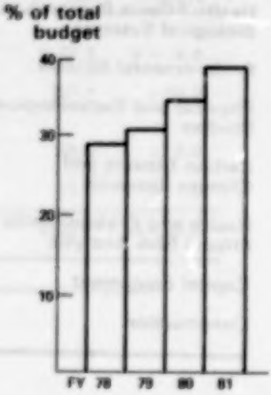
budget authority in millions

by technology	FY 1980	FY 1981	Change
Fossil	$51.2	$64.1	$+12.9
Inexhaustible	12.3	14.4	+ 2.1
Nuclear Fission	62.8	65.4	+ 2.6
Multi-technology	24.7	25.1	+ .4
Capital Equipment	11.9	11.7	− 0.2
Construction	6.0	6.4	+ 0.4
			$+18.2

FOSSIL

operating expenses—budget authority in millions

	FY 1980	FY 1981	Change
Coal Extraction	$ 2.5	$ 2.7	$+ .2
Coal Combustion	14.1	16.1	+2.0
Synfuels			
Coal Liquefaction	16.3	19.1	+2.8
Coal Gasification	5.1	6.4	+1.3
Oil Shale	5.2	6.2	+1.0
Oil & Gas	1.8	2.2	+ .4
Carbon Dioxide Research*	6.2	11.3	+5.1



*Excludes Climate Research

Life Sciences/Nuclear Medicine

budget authority in millions

	FY 1980	FY 1981	Change
General Life Sciences	$22.9	$25.7	$+2.8
Nuclear Medicine Applications	17.6	20.0	+2.4
Program Direction	0.2	–	−0.2
Capital Equipment	1.5	2.9	+1.4
			$+6.4

Senator **Matsunaga**. Thank you very much, Mrs. Clusen.

The Department of Energy role in the Federal Government phenomenon of acid rain is somewhat undefined. Do you have any other agencies looking into this or is this solely within the role of the Department of Energy?

Mrs. **Clusen**. The Environmental Protection Agency also has a very well-defined interest in this particular question. The interagency committee has representatives from a number of Federal agencies. I can provide you with a charter of that if you wish.

Essentially, in laying out a plan of research, we are attempting to look at what we already have so as not to duplicate what other agencies are doing.

Our research questions, with regard to acid rain, are almost totally directed to long-range transport of emissions from energy related sources and their dry or wet depositions.

Senator **Matsunaga**. In your statement, you state that you wish to maintain a strong and viable voice within the Department. Yet under the Department of Energy Organization Act, Public Law 95-91, the Secretary is given the authority to assign the environmental functions of the Department as he sees fit.

In addition to creating an Office of Environment, I note that the Secretary has also assigned certain environmental functions to other assistant secretaries. Would you describe the environmental functions of the Department assigned to these other offices and to your Department and the liaison mechanism between these offices and yours?

Mrs. **Clusen**. Mr. Chairman, I do not know of any specific environmental functions assigned to any other assistant secretary. Environmental functions are all assigned to my office. But there is research done in the environmental field by each of the technologies.

For instance, in the case of Mr. Fumich, fossil energy does do some research related to the processes in which they are involved. But the environmental responsibility of the Department of Energy is totally in my office.

The DOE Organization Act lays out the mandate. Actually when the Department was organized, the Secretary did, in his infinite wisdom, assign all of those functions to the Office of Environment.

Senator **Matsunaga**. I am glad to hear that because so frequently we find duplication of effort and consequently use of funds which could be much more efficiently used.

Senator **Melcher**. Do you have any questions?

Mrs. Clusen, I suppose no one knows at this time how much of this total function within the Department of Energy will remain after the President revises his budget. Do you have any insight?

Mrs. **Clusen**. I have no more information than you do at this point.

Senator **Melcher**. While I am not going to quarrel with the goal of your office within the Department of Energy, you are going to be doing a substantial amount of work trying to alleviate environmental degradation. Let us talk about fossil fuel for instance.

We do not seem to get very good results very fast in those types of newer technologies utilizing fossil fuels that would avoid environmental degradation. I am thinking specifically of MHD. You are going to have $64 million, I take it, to be spent under this budget to avoid environmental degradation for the use of fossil fuels. Is that about correct?

Mrs. CLUSEN. The $64.1 million request for fiscal year 1981 includes all forms of fossil, including synfuels research. It includes all of the CO_2, all of the work on oil shale, and all of the work on coal in any form. It is a broadly based program of everything related to fossil.

We use the term "environment" in a broad sense and we're looking at much more than physical and environmental degradation. We are looking at health effects, characterizing what is in the particulates and in the emissions, including some carcinogens. It is environment in the broadest sense of the word.

Senator MELCHER. Yes, when I was using the term, I was including, of course, public health which is probably the most significant critical part of environmental protection, at least in the case of utilization of fossil fuels.

Would it be advantageous to advance such technologies as MHD which, after all, is pretty basic to the use of coal for generation of electricity? The process of MHD, according to Mr. Fumich, would indeed eliminate any health hazard from sulfur dioxide, nitrous oxide, and it would minimize the threat of acid rain.

It seems rather odd to me that the Department of Energy does not come forward with something that alleviates part of the problem.

Mrs. CLUSEN. We have had in the Office of Environment very little to do with the MHD program as such. We are, however, doing some research on the effects of magnetic fields. Dr. Burr is head of the Health Environmental Research Office. Can you think of anything we're doing in MHD?

Dr. BURR. The program that relates closest to MHD is the work we are doing, trying to look at the potential effects of working around high magnetic fields. That is a concern that has not been explored adequately at present.

Senator MELCHER. You are concerned with all the environmental impact statements necessary for the Department of Energy as well as comment from other agencies for that portion which does involve energy production. Is that correct?

Mrs. CLUSEN. That's right.

Senator MELCHER. At what point will you be developing the environmental impact statement for the next phase of the MHD program?

Mrs. CLUSEN. The process works like this. We do not write environmental impact statements in my office. We simply do not have the personnel to do that. Nor are we the technologists. We work with technology people to help them write their environmental impact statements, keeping them informed as to what needs to be covered.

The role of my office is to overview and eventually to approve or disapprove the environmental impact statement when it is ready to be issued. I can't tell you about the timing because it would depend on when it comes from the technology.

Senator MELCHER. Then it would be up to the research and development people actually engaged in that function.

Mrs. **Clusen**. Yes, they would have to be initiated there.

Senator **Melcher**. Thank you.

Senator **Matsunaga**. Senator Bellmon.

Senator **Bellmon**. Thank you, Mr. Chairman. I have a few questions. Let me ask about the acid rain and CO_2 problems. It would seem to me that we may be in a sort of chicken and egg situation. Perhaps we are going to have to utilize a lot more coal before you will know whether or not acid rain is really a problem.

Yet you need to know if it's going to be a problem before we really shift over and convert to heavier coal utilization. Can you give us a reading on the acid rain situation before conversions from other forms of energy are made?

Mrs. **Clusen**. I think there is no question but that we know there is a problem now.

Senator **Bellmon**. But we do have to use more coal, that's a resource we have in abundance?

Mrs. **Clusen**. That is correct.

Senator **Bellmon**. Are you going to be able to tell us one of these days that we can use more?

Mrs. **Clusen**. We are monitoring at seven different sites at the present time. We are funding with EPA a joint operation. I can't envision when we are going to know enough to say definitively one way or the other, but I don't think any of us is anticipating that we are going to be in a position of saying that we must totally stop the use of coal.

What we are looking at are some answers that will help us mitigate the effects. Is there, for instance, any kind of control technology that would prevent those kinds of emissions? Is there anything in the process that could be done? These are the things we are looking at. The problem is already there.

Senator **Bellmon**. The problem is not there unless we burn a lot of coal.

Mrs. **Clusen**. I think we're all assuming that we are burning coal and will continue to burn more coal given the national policy at this time. Of course, we are also interested in looking down the road at synthetic fuels.

Senator **Bellmon**. If I were an executive officer of a large public utility using imported crude oil or imported oil, and I came to your agency, could you tell me whether or not, if I shifted over to coal or built a new plant using coal, that I might be someday shut down because of the acid rain problem?

Mrs. **Clusen**. My advice at this point would be to burn coal using the cleanest possible processes, adhering to the current Federal environmental regulations, using coal washing.

Senator **Bellmon**. What you seem to be saying is that your agency is not now preventing the construction of coal burning utilities?

Mrs. **Clusen**. I think it's well-known that we are encouraging, through the utility oil backout legislation, conversion to coal. Obviously, we believe it can be done safely.

Senator **Bellmon**. So there is not that much concern about the acid rain problem?

Mrs. **Clusen**. It is not a new problem, it's been here quite awhile. We are looking at the degree of increase and we are also interested in finding out what the things are that we can do to prevent it, and that is what research is devoted to at this time. I think there is no truly definitive answer, but we can't recommend not using coal.

Senator **Bellmon**. You want to then more or less assure a public utility that if they do shift over to coal, they won't be later asked to shutdown the facility because of the acid rain problem?

Mrs. **Clusen**. One of the imponderables is that there are no regulations at this point that apply specifically to acid rain. Environmental regulations, of course, are set by the Environmental Protection Agency.

That is an imponderable, one of the uncertainties. But we know of no indications that would make that possible now.

Senator **Bellmon**. I think what I am concerned about is, if your agency goes on studying and studying and does not set regulation, the uncertainty is going to cause reluctance to utilize coal.

Mrs. **Clusen**. The Department of Energy and my office do not set environmental regulations. It would be done by someone else.

Senator **Bellmon**. But a good bit of the regulations will be based on the result of your research?

Mrs. **Clusen**. Our research would be made available to standard setting organizations like EPA. We do not set them.

Senator **Bellmon**. What I am getting at is how soon will we know how far we can go in the direction of coal utilization in this country so far as the acid rain question is concerned? If you are monitoring, will you someday come with the result? If so, how soon?

Mrs. **Clusen**. We certainly expect to have results. As I indicated in answering the Chairman's question, that is why the interagency committee exists so that we can pool our resources and our research and develop a cohesive program that will give us some answers.

Senator **Bellmon**. When can we expect the answers is my question?

Mrs. **Clusen**. I cannot tell you at this time because we are just in the beginning stages of the interagency committee.

Senator **Bellmon**. Can you take a minute to tell us how the interagency committee operates?

Mrs. **Clusen**. It is just now getting organized. There are representatives from several Federal agencies, both at the level of the principals and at the working level. They are in the process of gathering information about what is going on currently in research in the Federal Government in the acid rain field.

Senator **Bellmon**. There is a paradox that strikes me through this whole thing, Mr. Chairman, not only today but other days and other hearings. This country this year is going to be importing somewhere between $90 and $100 billion worth of foreign oil which could be cut off at any time. At the same time we are holding here 300 or 400 years of coal which could be used in many cases to substitute for oil, particularly as boiler fuel. Yet we don't seem to have ever gotten around to the job of making decisions necessary before we can concentrate on utilization of this abundant resource.

When you tell us that you're monitoring and forming a new committee and maybe sometime out in the bye-and-bye we are going to know something, I am beginning to wonder if the administration is really interested in shifting over to coal and from what you said I take it you are not. Are you going all out to get ready for utilization of coal?

Mrs. **Clusen**. I believe we are and not just through our efforts to look at the acid rain question. I think our request in relation to the carbon dioxide field, again demonstrates that we are trying to look at any impediments that might stand in the way——

Senator **Bellmon**. When will you have an answer on the carbon dioxide question?

Mrs. **Clusen**. This, again, is an interagency program.

Senator **Bellmon**. Who will have the answer? An interagency program says to me no one really is in charge.

Mrs. **Clusen**. I don't believe that is the case, sir, in this particular program. The National Oceanic and Atmospheric Administration, NOAA, is the lead agency. The CO_2 part of the research, which is being carried out through my office is our part of that plan. There is a very comprehensive plan and I would be delighted to send you a copy.

Senator **Bellmon**. I'm not interested in the plan, I would like to have a 1-page letter that says we are going to know something within a period of time so that we can get on with the burning of coal.

Mrs. **Clusen**. Part of the problem with CO_2, of course, and to a certain extent with acid rain, is that these are problems that do not stop at boundary lines. To some extent they are global problems, particularly CO_2, and they must be looked at in that framework.

Senator **Bellmon**. Does burning coal create more CO_2 than burning oil?

Mrs. **Clusen**. Any fossil fuel adds to the carbon dioxide in the atmosphere.

Senator **Bellmon**. That's right, so what difference does it make if you burn oil or coal as far as CO_2 is concerned?

Mrs. **Clusen**. Coal causes emissions at a higher level——

Dr. **Burr**. Of the global CO_2 right now, the combustion of petroleum accounts for more of the CO_2 than combustion of coal. Coal combustion leads to an estimated 37 percent of the annual CO_2 production.

Senator **Bellmon**. If you are burning that fossil fuel to generate 1,000 megawatts a day and you don't get anymore CO_2 burning coal than you do burning oil, do you?

Senator **Bumpers**. If I understand, he is talking about the difference between generating 1,000 megawatts with oil and 1,000 megawatts with coal. Which one produces the most CO_2?

Dr. **Burr**. That depends on the efficiency of the process, the content of the coal, and things of that nature.

Senator **Bellmon**. It wouldn't make any difference, you would get the same burning, I would assume. That's why I can't understand why you are raising the CO_2 bugaboos as an impediment to burning coal.

Dr. **Burr**. The question, your first question dealt with the switchover to coal. That—that was appropriate to CO_2.

Senator **Bellmon**. We're talking about CO_2.

Dr. **Burr**. It doesn't necessarily follow with CO_2. We are contributing to CO_2 when we burn any fossil fuel.

Senator **Bellmon**. That's right, and I don't see why the CO_2 problem has anything to do with burning coal. You are going to burn some kind of fossil fuel unless we go nuclear which we are not able to do.

Senator **Bumpers**. In either case, you are combining a carbon molecule with oxygen and that is what makes carbon dioxide. It does not make any difference if it is coal or oil, does it?

Dr. **Burr**. When you convert a carbon atom to CO_2, it doesn't matter where the carbon came from, no.

Senator **Matsunaga**. Senator Bumpers.

Senator **Bumpers**. Mrs. Clusen, is there a major study going on now on acid rain, the effects of it, and how much we can anticipate if we burn so much more coal than we are burning now? I thought there was supposed to be a major study on that subject.

Mrs. **Clusen**. The only major effort in that sense that I know of is the one which was initiated as a result of the President's message on acid rain and the formation of the interagency committee. There is some work going on through the Environmental Protection Agency in addition to ours. Let me see if anyone else knows—Dr. Burr?

Dr. **Burr**. The work the DOE is doing is primarily concerned with problems of transport, problems of how the material, how the acid materials, come down out of the atmosphere, questions of where they will go, how much offshore, how much to Canada, things of this nature.

Several years ago we did have effect studies and some of our laboratories are very good in this area. They have a great deal of expertise in the area of effects. Principally, the Brookhaven National Laboratory and Oak Ridge National Laboratory.

Much of the work we supported on the effects of acid rain was transferred to EPA in 1979 and we therefore have less work ourselves directly related to effects. But EPA has a substantial program in this area.

Senator **Bumpers**. Is there going to be any overlap? There is not much point in your office and Environmental Protection Agency doing the same studies.

Dr. **Burr**. That is the purpose of an interagency committee, to minimize overlap and take advantage of contributions from all participating agencies. Each agency has the advantage of the findings that other agencies can contribute in the areas they are working in.

Senator **Bumpers**. I read recently that two or three lakes in the Adirondacks are dead as a result of acid rain. Is that true?

Dr. **Burr**. There are studies that have shown that there have been substantial changes in those lakes. EPRI, the Electric Power Research Institute, has studies related to those lakes and other groups have as well.

We don't have studies on those particular lakes. But we are studying the acid fallout in the region, the whole Northeast region of the United States.

Senator **Bumpers**. Acid rain is due solely to the sulfur content of coal, is it not? It has nothing to do with carbon dioxide?

Dr. BURR. CO_2 has little to do with the acid rain problem, but acid rain has to do with nitrogen oxides as well as sulfur oxides.

Senator BUMPERS. OK, nitrogen and sulfur. What is the catalyst? Is it moisture plus sunlight that creates acid rain? When you emit sulfur and NO_x into the atmosphere, what combines with them to create acid rain?

Dr. BURR. Yes, moisture in combination with sulfur and nitrogen oxides.

Senator BUMPERS. It creates sulfuric acid?

Dr. BURR. Yes, sir.

Senator BUMPERS. If we could take all of the sulfur out of coal, would we eliminate the problem with acid rain?

Dr. BURR. As I pointed out, you have both the sulfur content and the oxides of nitrogen.

Senator BUMPERS. But it takes sulfur and nitrous oxide to make acid rain.

Dr. BURR. No, either one alone could produce acid rain.

Senator BUMPERS. Would it be sulfuric acid if you took all the sulfur out?

Dr. BURR. It would not be sulfuric acid anymore.

Senator BUMPERS. What kind of rain would it be called then?

Dr. BURR. It depends on which oxide of nitrogen is involved, it could be nitric or nitrous acid, it would depend on what oxide you were dealing with.

Senator BUMPERS. In either event, it is a very serious problem, is it not?

Dr. BURR. It is known to have occurred. We know the rain is becoming more acid. We are certain there are some effects associated with it and the extent of these effects and the significance of these effects is what people are trying to assess.

Senator BUMPERS. The President has ordered over 102 presently oil-fired generating plants to convert to coal over a several year period. I think he plans to convert 57 of those in the next 3 to 5 years, and the Government will subsidize that to the tune of about $3.2 billion.

The President says the Environmental Protection Agency has cleared those plants for conversion. Has EPA considered the effects of acid rain, or are they just talking about sulfur at the stack top plus particulate and air quality standards?

Mrs. CLUSEN. I think you would have to ask them. My assumption would be that they have looked at them within the framework of the present Clean Air Act regulations, since there are no standards for acid deposition.

Senator BUMPERS. We have two problems. One is acid rain and the other is the effects of CO_2 on the atmosphere. Every atmospheric scientist that has appeared before this committee has delivered ominous warnings about climatic changes which we can anticipate by massive burning of coal.

What, if anything, is your office doing in studying this so-called greenhouse theory?

Mrs. CLUSEN. A great deal, and I would welcome the opportunity for my scientists to brief you. Since we have had about the best scientific advice available on this question and in the development of our program, the major differences of opinion on point of view between some of the scientists who deal with this question is a matter of degree, the nature of the problem, and the time line involved.

We have arrived at a somewhat more conservative opinion than that which you were referring to. We would be very glad to discuss it with you. There is no doubt that there is a problem, there is no doubt but what we need to do considerable research.

There is a question about how near-term, how great the acceleration is at this point, and this is where the difference occurs in the interpretation. I think it is a point of view worth hearing.

Senator **BUMPERS**. I take it the budget you are submitting this afternoon was submitted before the President's balanced budget obsession?

Mrs. **CLUSEN**. That is correct.

Senator **BUMPERS**. You were going to get an 11-percent increase?

Mrs. **CLUSEN**. That is our request.

Senator **BUMPERS**. Do you have any idea what to anticipate when OMB knocks on your door?

Mrs. **CLUSEN**. I really don't.

Senator **BUMPERS**. Have you been asked to make your own assessment as to what you consider the most vital programs in your agency?

Mrs. **CLUSEN**. Yes, I have.

Senator **BUMPERS**. Have you done that yet?

Mrs. **CLUSEN**. Yes, I have.

Senator **BUMPERS**. Could you clue us in as to what you are going to tell the President you can get by without?

Mrs. **CLUSEN**. I'm sure you realize that determinations are made by OMB and the President and it would be premature for me to discuss them.

Senator **BUMPERS**. I hear everything will be premature until after the New York primary. I promise I will not tell if you clue us in. [Laughter.]

Mrs. **CLUSEN**. I really do not know.

Senator **BUMPERS**. Mrs. Clusen, some of this testimony is pretty elusive to a layman. I am not a scientist. I am not familiar with your programs over there and the assessments and different acronyms you use. The task of this committee is to determine what you are doing and whether your budgetary request is justified or not.

On page 12 at the top of the page, the testimony reads:

> During fiscal year 1981, environmental development plans will be revised and updated for about 30 evolving energy technologies. Environmental readiness documents—

Whatever they are—

> will be generated or updated for some 22 technologies and project environmental plans will be prepared or revised for 65 to 75 major energy system projects in accordance with DOE project management system.
>
> The environmental impact activity assesses potential environmental impacts of energy policies and plans and performs environmental risk uncertainty and economic analysis. In fiscal year 1980, efforts will include issuing annual environmental analysis report and the assessment of the Energy Information Administration second annual report to Congress.
>
> Major tasks will be undertaken in 1981 and will involve the preparation of an updated AEAR and impact assessments for the third national energy plan and the fourth EIA report to Congress. Methods for linking long range air pollutant transport models to a regional residuals simulation model will be developed. Also, esti-

mates of costs and the economic impacts of pollution abatement will be improved and expanded.

What is the method for linking long range air pollutant transport models to a regional residual simulation model?

Mrs. **Clusen**. I think the best source for that is——

Senator **Bumpers**. Is the man who wrote the testimony present?

Mrs. **Clusen**. I can tell you what I think it is in layman's language, which is really looking at our long range air pollutant transport problems and how they will affect specific regions of the country.

Senator **Bumpers**. Mrs. Clusen, let me say this. With all due deference to you, this testimony is replete with that kind of thing. I will not speak for anyone else on the committee, but it is very difficult for me to make very much sense out of it.

I have other duties besides worrying about the Environmental Assessment Office at Department of Energy, and yet I consider you a fine woman and a good administrator. I am just saying this is very arcane and esoteric for a nonscientist. I wish the testimony communicated a little better. My staff and I will go over it and try to figure it out.

Mrs. **Clusen**. I have made a determined effort, since I am not a scientist, to translate our statement and I think we've made some strides. We would be glad to do whatever we can for you to help you understand what we really do and you have my word that we will try to do better next year.

Senator **Bumpers**. In order to be elected to this office, you have to be able to communicate, and my folks have to know what I am saying when I talk to them. They may not agree with me, but they at least have to understand me. I think it is equally important that the people who come over here to testify before this committee be able to communicate with us.

I can tell you based on what I know right now, if somebody said let us cut that budget $50 million, I would say that is fine with me because I do not know what they are using the money for, anyway.

Mrs. **Clusen**. I understand your problem. I wish there had been enough time for me to go through the full oral summary, which would be of course my attempt to translate what it says for you. In deference to the request of the committee, I did a very quick job of that and that might have been my mistake.

Senator **Bumpers**. Thank you, Mr. Chairman.

Senator **Matsunaga**. Thank you, Senator Bumpers.

Senator **Bumpers**. I have one other question, Mr. Chairman, if I may. We are not likely to try to commercialize fusion before the year 2010. Do you consider it premature to be spending very much money on the environmental effects of fusion?

Mrs. **Clusen**. I think it is down the road quite a way. At this point we, in our office, are not giving it a high priority because we have nearer term questions to deal with.

Senator **Bumpers**. Thank you, Mr. Chairman.

Senator **Matsunaga**. I would like to voice the views and attitude expressed by Senator Bumpers. That is the way I feel, as though I am reading sometimes just the way I am talking. You do not understand me, do you? As the former head of the League of Women Voters, I think some of the testimony which you have presented, you would object to very strenuously as not being communicative.

I might say this. One of my biggest concerns is disposal of nuclear waste matter. Out of the 70-odd plants now operating throughout the United States, I understand we have about 2,100 tons annually of highly radioactive waste matter being spewed forth.

In your opinion, do we now have a safe way of disposing of this highly radioactive waste matter which I understand will remain dangerous to human life for the next 2,500 years?

Mrs. CLUSEN. I think at this point I can only say safely that we have a couple of quite good possibilities. We have learned, for instance, that through the use of some sort of geologic formation it's possible to do this kind of thing. In addition to that, we have also been looking at some vitreous process which is the use of glass—you can explain this better than I can, Dr. Burr, because we've been looking at a couple of things that we think offer some hope.

Senator MATSUNAGA. This is a process of neutralizing——

Dr. BURR. This would be a form in which they might put the material for long-term storage. That research really does not fall under us specifically. We are interested in the environmental problems associated with disposal activities.

Mrs. CLUSEN. There is a separate Office of Nuclear Waste within the Office of the Secretary of Nuclear Energy that deals with this more specifically. We look at the environmental effects and the safety of the processes. That has been the only part of it we have been involved in as yet.

Senator MATSUNAGA. I was somewhat disturbed to hear you say that you have not placed high priority on nuclear fusion. The answer to nuclear fusion would be the answer to nuclear energy, would it not?

When I was visiting over at Lawrence Livermore Laboratories, I was told that the answer might be within our grasp in the next 10 or 15 years and not 50 or 75 years as I was initially told. With priority, if we find the answer to nuclear fusion, we will not need to worry about coal gasification, liquefaction, et cetera.

Mrs. CLUSEN. There is much in what you say. However, in the Office of Environment, to a certain extent, we are driven by the priorities of the Department. At this point, the Department is treating fusion as something that is not near term.

We, however, are looking at the health and environmental impacts of fusion reactors. We are attempting to do some things so that we will be ready and we are looking at the biological effects of some of the gas releases to see if any changes might result from exposure to this sort of thing.

We are trying to position ourselves so that we will know enough when the time comes. But the Department's policy in regards to fusion, of course, is not within my hands.

Senator MATSUNAGA. It is 4:32 now and I have another appointment.

Senator BUMPERS. I have no further questions.

Senator MATSUNAGA. We thank you very much, Mrs. Clusen. We may have other questions which we may submit to you in writing, and we would appreciate your responding in writing for the record.

Mrs. **Clusen**. I will be glad to reply in as clear language as I can.

Senator **Matsunaga**. We would appreciate that very much. Thank you very much. The subcommittee stands in recess.

[Whereupon, at 4:33 p.m. the hearing was recessed, to reconvene, Thursday, March 20, 1980.]

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DEPARTMENT OF ENERGY FISCAL YEARS 1981-82 AUTHORIZATION

(Civilian Applications)

THURSDAY, MARCH 20, 1980

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
OF THE COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:28 p.m., in room 3110, Dirksen Office Building, Hon. Frank Church, presiding.

Present: Senators Church, Bumpers, Matsunaga, and McClure.

Also present: Willis Smith, professional staff member.

Senator **BUMPERS** [presiding]. The subcommittee will come to order.

Senator Church will be along shortly, but in the interest of expediency I will insert his statement and we will start the hearing.

[The prepared statement of Senator Church follows:]

STATEMENT OF HON. FRANK CHURCH, A U.S. SENATOR FROM THE STATE OF IDAHO

Today the Subcommittee on Energy Research and Development continues its hearings on the President's 1981 fiscal year budget request for the Department of Energy with an examination of the Office of Conservation and Solar Energy programs. Testifying before the Subcommittee today will be Dr. Maxine Savitz, Deputy Assistant Secretary for Conservation and Dr. Bennett Miller, Deputy Assistant Secretary for Solar Energy (Designate).

We begin the examination of the 1981 fiscal year request at a time when both the administration and many Members of Congress are calling for massive budget cuts with the ultimate goal of a balanced budget and a substantially-reduced rate of inflation. We, as members of a subcommittee that reviews the budget request for the Department's research and development activities, can play a constructive role in this debate. In these days of runaway inflation, we certainly must tighten our belt and reduce spending, but only by cutting the fat out of government, not the heart! At a time when it is absolutely imperative for the United States to lessen its dependence upon imported oil, we can ill afford to cut back on the programs that have greatest potential for getting us to our energy-independence goal in the shortest period of time. While Ben Franklin's suggestion of "a penny saved is a penny earned" generally remains a sound piece of advise, it could be a shortsighted way of approaching our energy Budget Review. For every penny we "save" by cutting back on promising energy research and development projects, we can only expect to "earn" a growing reliance on OPEC cartel oil. Therefore, for every penny we "save" by choosing not to invest in promising R. & D. activities, we could be handing over to OPEC not only our original investment, but also some additional "earnings" as well.

That is not to say that all research and development projects are worthy of continued funding. We must carefully scrutinize these activities and with the understanding that we have only a very limited amount of money to spend, we must choose to emphasize the funding of programs which are likely to give us the best result, the largest payback, in the shortest amount of time.

Therefore, I am most interested in discussing today not only the funding levels for each program, but also the overall priorities of the Department and how these priorities are reflected in the individual program activities. Dr. Savitz, for example, notes in her prepared statement that the transportation sector consumes 53.7 percent of the nation's supplies of petroleum products. The Department concluded in its own "Report of the Alcohol Fuels Policy Review" which was released last June, "that ethanol is the only alternative fuel commercially available now and the only one likely to be available in quantity before 1985." What I would like to know is whether Dr. Savitz's transportation program office is placing an appropriate amount of emphasis on alcohol fuels based on the priorities established in Dr. Miller's Office of Alcohol Fuels. Are these same priorities reflected in the Department's biomass activities?

In the industrial program area, why has the waste energy reduction program focused on only a few industries? Are we giving adequate attention to those industries where the savings potential are greatest?

Given our fiscal constraints, we must weigh all programs, existing and proposed, and decide whether the funding of each program measure can be justified at an enhanced, existing or reduced level based on the near-term potential of competing program measures.

The bottom is that every penny spent by the Department must produce the maximum number of Btu's in the minimum amount of time. Only if we approach budget trimming in this fashion can we hope to lessen our reliance on imported oil, which in reality is the only way we are going to slow down our runaway inflation and, in doing so, improve our Nation's economic situation.

Senator **Bumpers**. Our first witness is Dr. Bennett Miller, Deputy Assistant Secretary for Solar Energy.

Dr. **Miller**. I would like to ask that Dr. Savitz be the leadoff witness. She will be talking about organization, and she has to make a plane this afternoon.

Senator **Bumpers**. Fine.

STATEMENT OF DR. MAXINE SAVITZ, DEPUTY ASSISTANT SECRETARY FOR CONSERVATION, DEPARTMENT OF ENERGY

Dr. **Savitz**. I would like to submit my total statement for the record, and I will then summarize.

I am pleased to be here today to submit the fiscal year 1981 budget request for the Office of Conservation and Solar Energy to the Subcommittee on Energy Research and Development of the Senate Committee on Energy and Natural Resources. I will briefly discuss our new organization, just approved last month in order to accomplish the mission of developing and promoting energy conservation activities and the use of renewable resources.

The Office formulates and administers the Department's energy conservation programs, for which I am responsible. These programs are designed to improve the energy efficiency, storage, and systems utilization capabilities of the Nation's major energy end-use sectors, including transportation, buildings, community systems, and industry.

Second, as a result of an agencywide realinement of functions to October 1979, the Department's solar programs have been consolidated under this Office. All the necessary programs, from technology research, development, and demonstration to market analysis and application, are now reporting to the same Assistant Secretary, including the Solar Energy Research Institute and the four regional Solar Energy Centers. We are taking strong management steps to improve the operation and interrelationship of these important field institutions.

Finally, CS is forming a partnership with State and local governments through the administration of grants, technical assistance, and outreach programs to accelerate the widespread application of both conservation and renewable resources.

Four Deputy Assistant Secretaries, including Dr. Miller. and myself, have been designated to provide Dr. Stelson, the Assistant Secretary, with the management and administrative support required to insure that the full spectrum of CS activities is managed properly.

Each Deputy has been given responsibility for specific programs and functions, including: Energy conservation, solar energy, state and Local programs (including small scale technology, inventions program, and emergency programs), and field operations and international programs.

Senator BUMPERS. Before you continue with all of those programs, can you tell us, on the front end, if these requests are a reflection of the original budget? These are not figures that have been given to you in the last few programs regarding new proposals, are they?

Dr. SAVITZ. No. All the numbers I am speaking about today were submitted in January.

For fiscal year 1981, the Department is requesting $1.79 billion in budget authority and a total of 911 full-time permanent positions, 652 of which will be in headquarters and 259 in the field. I will highlight the CS budget request for the major conservation program areas. Dr. Miller will follow with a discussion of the solar program areas.

The President, in his state of the Union address, designated 1980 as "the year of energy conservation." The Department's conservation programs are designed both to promote readily available conservation technologies—or those that will save energy in the short term—and to provide for the necessary research, development, and demonstration for technologies that can meet our energy needs in the future.

Specifically, for fiscal year 1981 we are requesting $97.6 million for buildings and community systems programs. Approximately $74.9 million of this amount will be devoted to R. D. & D. activities, and $16.6 million will be spent on near term commercialization activities.

The activities undertaken by the Office of Buildings and Community Systems are shaped along program thrusts, each representing a major energy end-use area. The thrusts are:

Consumer products, which include appliances, furnaces, air-conditioners, lighting equipment, and similar building elements.

Building systems, which include the building envelope.

Community systems, which include the facilities that provide energy to a community, such as district heating and urban waste-to-energy projects and energy-efficient community planning.

BCS also has responsibility for the Federal Government's own energy conservation activities as well as other efforts.

The $22.2 million requested for technology and consumer products will support the development and field testing of advanced heating and cooling equipment.

The budget supports research on condensing mode gas- and oil-fired burners that will deliver more than 90 percent seasonal efficiencies compared with current efficiencies of 65–70 percent.

The program was instrumental in the commercial introduction this year of four different models of gas- and oil-fired burners with system efficiencies over 80 percent.

The buildings systems activity, for which we are requesting $20.1 million in 1980, supports research, development, and demonstration programs to advance the understanding of energy use in buildings.

The 1981 program will focus on energy savings that can be achieved in ventilation, service water, and illumination. A high priority will be given to identifying and reducing any health hazards in cellulose and urea formaldehyde insulation or other conservation measures.

The development of building energy performance standards is also supported by this item.

The proposed rulemaking for the building energy performance standards was published in November 1979, and the final standards are scheduled for publication in August 1980. The standards bring together a broad spectrum of research into a national strategy for energy efficient new buildings.

The fiscal year 1981 request for community systems is $15.5 million. The urban waste request is $10.9 million, and the small business request is up slightly to $750,000. The energy-saving opportunities in these programs range from subdivision developments to comprehensive planning in major metropolitan areas.

The program includes a technological element that supports research, development, and demonstrations of innovative energy systems, such as integrated community energy systems and district heating. During 1981, construction is expected on three integrated systems.

The program also supports a community planning and management activity.

The urban waste appropriation supports applied research on waste-to-energy systems, demonstrates a wide range of technologies and seeks to find solutions to generic institutional and economic problems. For example, a refuse conservation to energy facility in Pompano Beach, Fla., which converts municipal solid waste and sewage sludge into methane, will start operating under commercial conditions in fiscal year 1981.

The small business appropriation is aimed at reducing the energy costs of the Nation's 9.4 million small businesses by providing information and technical assistance.

We are requesting $58.9 million in budget authority for industrial programs in fiscal year 1981. Approximately $51.8 million will be devoted to R. D. & D. activities and $4.5 million to near-term commercialization activities.

The fiscal year 1981 program in general is designed to deepen the penetration of previously demonstrated new technologies and broaden the base of the new technologies by stressing the completion of previously initiated projects.

During fiscal year 1979 and the beginning of fiscal year 1980 the Industrial Programs Office had several notable accomplishments, including:

An additional 5 foam finishing installations were brought on line, for a total of 14 in the textiles industries in the southeast; advanced topping cycle cogeneration demonstration projects were established in four industrial applications, including textiles, chemicals, food processing and metal fabrication.

The objectives of the Industrial Programs Office for the remainder of 1980 include, among others:

Full-scale industrial demonstrations of new technologies, including textile foam processing, improved slot forge furnaces, high temperature ceramic recuperators and plastic waste to fuel oil conversion; and initiation of contracts to develop an environmentally acceptable cokemaking process.

The fiscal year 1981 budget request for Industrial Programs Office falls under four specific subprogram areas:

The waste energy reduction subprogram supports the development of technologies that will permit efficiency improvements and fuel substitution in processes that are common to many industries. Most of these funds are for the continuation of projects begun in earlier years, such as the hardware phases of industrial heat pumps and tube oil rerefining.

The fiscal year 1981 request for industrial process efficiency will support the research and development of process-specific technologies, with applications in the most energy-intensive industries, including steel, aluminum, paper, textiles, agriculture, and food processes. During fiscal year 1981, activities will include testing of commercial-size aluminum reduction cells, and demonstrations of mechanical dewatering of paper, efficient motors and crop drying systems.

During fiscal year 1981, the Industrial Programs Office also will continue to support a broad spectrum of activities designed to further develop and commercialize industrial cogeneration systems.

We are requesting $113 million in fiscal year 1981 for CS transportation programs. Approximately $106.3 million of this amount will be devoted to R. D. & D. activities and $6.7 million for near-term activities.

As in other program areas, the Department's transportation program involves information dissemination, financial assistance, and research, development and demonstration designed to lead to the early commercialization of fuel efficient technologies, including technologies capable of using energy sources other than petroleum.

Two examples of significant accomplishments during fiscal year 1979 and the first quarter of fiscal year 1980 are:

Pilot testing was completed and regular revenue service began on a turbocompound diesel heavy duty truck engine. Potential fuel savings are on the order of 8 percent.

In alternative fuels R. & D., five automobiles were modified and tested for use of straight alcohol to demonstrate three competing fuel management systems.

During the remainder of calendar year 1980, the Transportation Program Office has established a number of objectives, including, among others:

To begin development of two gas turbine concepts, with ceramic components, for passenger cars, which have the potential to increase fuel economy by 30 percent, meet stringent emission standards, and burn a wide variety of fuels; and

To add 350 vehicles to the electric vehicle demonstration; and to test and evaluate 2 prototype electric vehicles designed from the ground up.

The $113 million budget for the Office of Transportation Programs is divided into four categories:

Vehicle propulsion R. D. & D., which supports further development of gas turbines and the stirling engine, among other technologies, and fuel phases of the urban gas turbine demonstration.

Electric and hybrid vehicle R. D. & D., which supports the ongoing demonstration program; product improvement and near-term battery development; advanced hybrid propulsion subsystems, continuously variable transmissions and commercialization activity.

The transportation systems utilization area distributes information on fuel economy and energy conserving operation and maintenance techniques. It also supports conservation in all intercity passenger and freight transportation modes.

The alternative fuel utilization program supports extensive reliability testing and development activities associated with the use of alternative fuels, particularly alcohol in vehicles.

We are requesting $82.8 million for fiscal year 1981 programs in advanced conservation technologies, of which $71.8 million will go toward energy storage systems, and $11 million to support new, more fundamental research in energy conversion and utilization technologies.

The major thrusts of the energy storage systems are to develop:

For electric and hybrid vehicles—improved propulsion batteries and flywheel regenerative braking systems;

For heating and cooling buildings—aquifer storage for seasonal applications, thermal storage for daily cycling applications, and phase change and chemical heat pump storage for solar applications.

For solar and conventional electric utility applications—battery, thermal, mechanical, magnetic and underground—compressed air, pumped hydro—storage.

For industrial and multipurpose uses—energy saving electrochemical processes, retrofit thermal storage for industrial heat recovery, and economical processes for producing hydrogen.

During the past year, industry has cost-shared energy storage R. & D. by providing almost 30 percent of the total DOE support. One example of a recent accomplishment is: For electric and hybrid vehicles, the first full size near-term electric vehicle battery cells—lead-acid, nickel/iron, and nickel/zinc—have been tested at the National Battery Test Laboratory.

During the remainder of 1980, energy storage systems expects to achieve the following objectives, among others:

Complete fabrication of a full-size hydrogen electrolyzer for test as a special source of hydrogen for chemical use.

Complete design of a waste heat storage system for sterilization processes in a food processing plant in North Carolina.

In fiscal year 1981 the battery storage program area will emphasize near-term development of zinc/chlorine electric vehicle batteries and acceleration of the capability of the National Battery Test Laboratory.

The fiscal year 1981 budget request for thermal and mechanical energy storage will provide increased support for the nearterm development of underground mechanical storage systems, but the major emphasis of the program will continue to be the development, demonstration and testing of thermal storage technologies for solar applications.

The budget request provides $11 million to support more basic research and development of energy conversion and utilization technologies. This is a new activity to be initiated in fiscal year 1981. Activities in the general areas of combustion, controls, materials processes and biochemical technologies are being considered. A research agenda is currently being developed in consultation with the academic and private sectors.

The fiscal year 1981 budget request provides $151.6 million to support grants to States and local governments under the President's proposed Energy Management and Partnership Act. The State activities supported by several existing programs, such as the Nationwide Energy Extension Services, will be extended by EMPA, which is intended to consolidate and strengthen State energy activities rather than to redirect them.

The fiscal year 1981 budget also provides a total of $20.6 million for the appropriate technology small grants and inventors programs.

The appropriate technology small grants program is budgeted at $14.8 million. This program, established by Public Law 95-39, has provided over 600 grants of less than $50,000 each since its inception. The increased funding for fiscal year 1981 will be used to make 125 more grants and support efforts to encourage the more widespread application of small-scale renewable technologies.

The Inventors Program, established by Public Law 93-577, evaluates and provides assistance for promising energy related inventions. During fiscal year 1981, the office plans to provide $2.4 million to NBS to support their efforts and to allocate $3.4 million to support an additional 40 grants for the development of recommended inventions.

Mr. Chairman, I will be happy to answer any questions.

Senator CHURCH [presiding]. Thank you, Dr. Savitz.

[The prepared statement of Dr. Savitz follows:]

STATEMENT

OF

DR. MAXINE SAVITZ

DEPUTY ASSISTANT SECRETARY

FOR CONSERVATION

DEPARTMENT OF ENERGY

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

MARCH 20, 1980

The subject of the testimony this morning by Dr. Miller and myself is the President's fiscal year (FY) 1981 budget request for the Department of Energy's (DOE's) Office of Conservation and Solar Energy (CS).

I will cover those programs which are designed primarily to support the research, development and demonstration of energy conservation technologies and to develop more effective techniques for energy storage.

The need for energy conservation and the increased use of renewable resources is particularly critical at this time in the Nation's history. Escalating costs of energy and increasing dependence on foreign petroleum threaten our economic prosperity, aggravate inflation, weaken our currency, and constrain our foreign policy.

Energy conservation is the elimination of waste and the investment in more efficient buildings, machines and consumption patterns. Renewable resources, principally the many forms of solar energy, obviate the need for additional foreign oil and extend existing domestic supplies. In this respect, conservation and renewable resources compliment one another and are vitally important to enhancing our overall national security.

The full potential of conservation and renewable resources will be achieved only through a concerted effort to overcome a variety of barriers to their use, principally institutional, economic, regulatory and attitudinal barriers. Over the next 30 years, conservation can contribute more than any other single source of energy supply to meet the Nation's additional energy needs. The CONAES study recently released by the National Academy of Sciences concluded that through energy conservation it is technologically feasible for the United States' projected energy requirements in the year 2010 to be met by 26 percent less energy than would be required using today's level of energy efficiency. While this rather optimistic scenario may not be achieved, it is important to keep in mind the large potential that exists. Other studies such as the Harvard Business School Report: Energy Future and the Ford Foundation's Energy: The Next Twenty Years all support a similar conclusion. These studies are also in general agreement with the findings of the President's Domestic Policy Review of Solar Energy, which states that the many forms of renewable energy resources can contribute a significant portion of the total energy required to meet our needs by the end of the century.

The mission of the Office of Conservation and Solar Energy is to develop and promote energy conservation and the increased use of renewable resources, and thus further several important national goals. These include:

- Less reliance on imported fuels in order to reduce our vulnerability to shortfalls or disruptions created by fluctuating world economic and political events.
- A more even balance of trade, through reduced imports, to achieve a more stable domestic and international economy. Our imports of oil last year exceeded $60

billion which is the major contributing factor to our balance of payment deficits.

- And finally, accelerate our transition from a reliance on oil and natural gas to the greater use of coal and renewable resources as primary sources of domestic energy supplies.

Organization

To accomplish its mission, the Office of Conservation and Solar Energy encompasses three groups of programs and activities. First, the Office formulates and administers the Department's energy conservation programs for which I am responsible. These programs are designed to improve the energy efficiency, storage and systems utilization capabilities of the Nation's major energy end-use sectors, including transportation, buildings and community systems, and industry. Second, as a result of an agency-wide realignment of functions in October 1979, all of the Department's solar programs have been consolidated under this Office and are the responsibility of Dr. Bennett Miller. All the necessary programs from technology research, development and demonstration, to market analysis and application are now reporting to the same Assistant Secretary, including the Solar Energy Research Institute (SERI) and the four Regional Solar Energy Centers (RSEC's). We are taking strong management steps to improve the operation and interrelationship of these important field institutions. Finally, CS is forging a partnership with State and local governments through the administration of grant, technical assistance and outreach programs to accelerate the widespread application of both conservation and renewable resources.

Four Deputy Assistant Secretaries have been designated to provide the Assistant Secretary with the management and administrative support required to ensure that the full spectrum of CS activities is managed properly. Each Deputy has been given responsibility for specific programs and functions, including myself as Deputy Assistant Secretary for Conservation, Dr. Bennett Miller as Deputy Assistant Secretary for Solar Energy, a Deputy Assistant Secretary for State and Local Assistance Programs (including Small Scale Technology, Inventions program and Emergency programs) and a Deputy Assistant Secretary for Field Operations and International Programs.

For FY 1981, the Department is requesting $1793.7 million in budget authority and 880 full time permanent staff for programs managed by the Assistant Secretary for Conservation and Solar Energy. An additional 31 positions are being requested for management and support activities for a total of 911 full time positions. Of this number, 652 positions will be for headquarters and 259 for the Regional Offices to administer CS programs in the field.

The attached chart provides a summary of the conservation and solar energy budget as it relates to the three major program groups--Conservation, Solar Energy, and State and Local Assistance.

OFFICE OF
CONSERVATION AND SOLAR ENERGY
OPERATING EXPENSES, CAPITAL EQUIPMENT, AND CONSTRUCTION
(BA IN MILLIONS)

	FY 1980 1/ BA	FY 1981 BA	CHANGE BA
BUILDINGS & COMMUNITY SYSTEMS	$ 103.4	$ 97.6	$ -5.8
INDUSTRIAL PROGRAMS	60.2	58.9	-1.3
TRANSPORTATION PROGRAMS	116.4	113.0	-3.4
STATE & LOCAL PROGRAMS	439.6	568.6 2/	+129.0
APPROPRIATE TECHNOLOGY	12.6	14.8	+2.2
INVENTOR'S PROGRAM	6.4	5.8 3/	-0.6
ENERGY CONVERSION TECHNOLOGY	0	11.0	+11.0
SOLAR ENERGY	596.2	652.2	+56.0
ENERGY STORAGE SYSTEMS	66.3	71.8	+5.5
ENERGY IMPACT ASSISTANCE	50.0	150.0	+100.0
ENERGY INFORMATION CAMPAIGN	0	50.0	+50.0
TOTAL CS	$1,451.1	$1,793.7	$+ 342.6

1/ excludes FY 1980 supplemental request

2/ excludes impact assistance

3/ includes support to NBS

The programs that I will discuss today are designed largely to facilitate the development of technologies which must ultimately be made available by private industry and utilized by individuals and businesses. These programs are designed to overcome one of the key barriers which deter private actions supportive of energy conservation in many areas -- the inability or unwillingness of private industry to support adequate research and development.

There are particular situations where the private sector is not investing in energy-related research and development at levels commensurate with the overall importance of conservation. In some cases, energy research involves risks which the private sector is unwilling to bear alone. In others, private firms have been reluctant to spend resources for research and development on energy if they believe it is likely that their competitors will share any benefits without comparable investments. There are also few funding sources for small-scale, applied research.

To accelerate energy conservation, the Department is implementing a range of programs designed to overcome the major barriers to private action. While the emphasis of the Department's efforts differs depending on the characteristics of end-use sectors affected, each program area encompasses activities which fall into most or all of the following general categories:

- Public information,
- Financial incentives,
- Regulatory measures, and
- Research and Development.

Government-sponsored research and development is a tool for promoting conservation that is similar to financial incentives. Depending on the state of the technology, Federal support is directed at achieving a variety of different objectives, including the characterization of end-use market requirements, technical and cost assessments, prototype development and testing, full-scale demonstrations and associated commercialization activities. The overall objective of accelerating the widespread commercial application of conservation technologies is continually emphasized. Encouraging maximum industry participation through cost sharing and broad dissemination of research results is one method of achieving this overall objective. In 1980, the Department will have under way more than 250 research and development projects aimed at conservation improvements. Of these, more than 60 projects will produce prototypes or test units, and more than 90 projects will produce technical reports describing results. Again, these programs will continue in FY 1981, with a greater focus on the most promising energy conservation technologies.

There are four distinct program offices under my responsibility. Three of these offices are designed to conserve energy in each of the major end-use sectors: Buildings and Community Systems; Industrial Programs; and Transportation Programs. The other office, Advanced Conservation Technology, is designed to support the development of technologies which can be applied in all sectors: Energy Storage Systems and Energy Conversion and Utilization Technology.

BUILDINGS AND COMMUNITY SYSTEMS

The President's FY 1981 budget request for the Office of Buildings and Community Systems (BCS) is $97.6 million, a reduction of $5.8 million from the FY 1980 budget authority. The reduction reflects a number of shifts in program activity and the pursuit of building and community conservation objectives through programs outside the BCS budget area. The reduction does not reflect a lessening of DOE's commitment to conservation in this important area.

Strategy

The Federal strategy in the buildings and community area reflects the diffused and varied nature of energy consumption in this sector.

The Federal Government's buildings conservation programs include financial incentives, in the form of tax credits, grants and proposed loan subsidies, as well as information programs, efficiency standards for new buildings and appliances, and research and development activities. Numerous Federal agencies are involved in this overall effort. DOE's Office of Buildings and Community Systems (BCS) is the focal point for most of the information, regulatory and R&D activities, but its annual budget represents less than 10 percent of the Federal Government's total expenditures (including tax expenditures) on buildings energy conservation.

The activity of BCS is shaped along program thrusts, each representing a major energy end-use area. The thrusts are:

- Consumer Products, which include appliances, furnaces, air conditioners, hot water heaters, lighting equipment, heat pumps and similar building elements.

- Building Systems, which include the building envelope and the equipment in the building as it functions as an integrated energy system.

- Community Systems, which include the facilities that provide energy to a community, such as district heating and urban waste-to-energy projects, and energy-efficient community planning.

BCS also has responsibility for the Federal Government's own energy conservation activitites and this activity is placed in a fourth BCS division along with responsibility for systems analysis and emergency planning activities.

Consumer Products

The Consumer Products programs are funded primarily from two budget lines, Technology and Consumer Products and Appliance Standards.

The $22.2 million requested for Technology and Consumer Products will support the development and field testing of advanced heating and cooling equipment. The budget supports research on condensing mode gas- and oil-fired burners which will deliver more than 90 percent seasonal efficiencies, compared with current efficiencies of 65-70 percent. The DOE lighting program is developing lamps, fixtures, ballasts and daylighting techniques which could result in a 20 percent energy saving by 1985 compared to conventional lighting equipment.

The requested budget is a decrease of $7.4 million from FY 1980, because Congress added $9.0 million to this budget in FY 1980 to initiate the 40KW fuel cell field demonstration and additional funds for this purpose are not needed in FY 1981.

This area also encompasses our efforts to develop and implement Appliance Standards, which is budgeted at $7.9 million for FY 1981.

Accomplishments and Objectives

- The program was instrumental in the commercial introduction in 1980 of four different models of gas- and oil-fired burners with system efficiencies over 80 percent.

- Two products developed under the lighting program were introduced in FY 1980 into the commercial market: an advanced circline lamp marketed by Sears and solid state ballasts for 40 Watt fluorescent fixtures marketed by Beatrice Food.

Building Systems

The programs in this area are funded primarily through the Building Systems and Residential Conservation Service appropriations. The requests in these areas are up slightly over 10 percent in the FY 1981 budget to $20.0 million and $5.2 million, respectively. The programs focus on reducing energy waste in the Nation's existing buildings and on insuring that new buildings are energy efficient. DOE estimates that at least 40 percent of the energy used in the Nation's buildings is wasted.

The Building Systems activity supports reserarch, development and demonstration programs to advance the understanding of energy use in buildings. The 1981 program will focus on energy savings that can be achieved in ventilation, service water and illumination. A high priority will be given to identifying and reducing any health hazards in cellulose and urea formaldehyde insulation. Studies will examine the interior air quality of highly efficient homes and initiate efforts to solve any problems in this area. The program will examine innovative structures such as earth-sheltered and foam buildings.

The development of Building Energy Performance Standards is also supported by this item. The performance standards apply to the design energy requirements of whole buildings. By contrast, prescriptive standards set forth requirements for walls, ceiling, windows and other building components. The performance standard focus more directly on energy use, allow greater flexibility, and encourage the use of solar energy. The standards are expected to save more than 29 quads of energy between 1980 and 2020. The FY-1981 work will extend the standards to restaurants and industrial buildings, continue the revision of existing building codes so they can be equivalent to the standards, upgrade the computer program (DOE-2) for better analysis of active and passive solar systems, develop hand-held and desk-top calculators that determine a building's design energy requirements and provide training for building code officials.

Accomplishments and Objectives

- The proposed rulemaking for the Building Energy Performance Standards was published in November, 1979, and the final Standards are scheduled for publication in August, 1980. The Standards bring together a broad spectrum of research into a national strategy for energy effecient new buildings.
- Construction was being completed in 1980 for a facility that will test heat flow, infiltration and moisture migration in wall sections.

Community Systems

The programs in this area are funded primarily from the Community Systems, Urban Waste and Small Business appropriations. The FY 1981 request for Community Systems is $15.8 million, a reduction of $1 million from the prior year reflecting a decision to delay development of heat-pump based community energy systems and to provide for future support of local energy planning activities through the proposed Energy Management Partnership Act. The Urban Waste request is $10.9 million, down $2.1 million from the prior year. This reduction is a result of reduced requirements for R,D&D of methane-from-landfills, domestic waste water treatment and small scale systems. The Small Business request is up slightly to $750,000.

The energy-saving opportunities in these programs range from subdivision developments to comprehensive planning in major metropolitan areas. The program includes a technological element that supports research, development and demonstrations of innovative energy systems, such as Integrated Community Energy Systems and district heating. During 1981, construction is expected on three integrated systems. The potential for large scale heat pump systems will be assessed. A number of district heating projects will be continued.

The program also supports a community planning and management activity. Under the Comprehensive Community Energy Management Program (CCEMP), the participating communities will move toward the implementation of their plans in FY 1981. The Site and Neighborhood Design program will look at modifications in code regulations to allow more energy efficient designs.

The Urban Waste appropriation supports applied research on waste-to-energy systems, demonstrates a wide range of technologies and seeks to find solutions to generic institutional and economic problems. During FY-1981 emphasis will be placed on the development of small scale systems. A Refuse Conversion to Energy facility in Pompano Beach, Florida, which converts municipal solid waste and sewage sludge into methane, will start operating under commercial conditions. The ANFLOW system, an upward flowing digester process, will be scaled up to 50,000 gallons a day and will begin operation in Knoxville, Tennessee. Support will continue for 12 existing projects to recover methane from landfills.

The Small Business appropriation is aimed at reducing the energy costs of the Nation's 9.4 million small businesses. The program includes guidebooks for different small business sectors, outreach to trade associations and state energy offices and research to determine which conservation measures are of greatest importance to small businessmen.

Accomplishments and Objectives

o Four grid connected Integrated Community Energy Systems have resolved issues of financing, ownership, operation and rates and one is well into construction.

o The 22 communities which participated in the Comprehensive Community Energy Management Program have completed the development of local action plans and are starting to implement them.

- DOE has played a leadership role, in cooperation with others, to develop an advanced treatment and energy production system at the Experimental Prototype Community of Tommorrow at Disney World.

Other Programs

The remaining BCS programs are financed by the analysis and Technology Transfer and Federal Energy Management Program budget requests. The Analysis and Technology Transfer request increased slightly to $5.9 million. The Federal Energy Management Program request has increased sharply from $400,000 to $2.7 million.

INDUSTRIAL PROGRAMS

The FY 1981 budget request for the Industrial Programs Office is $58.9 million, a reduction of $1.4 million from the budget authority available in FY 1980. This reduction is not for any specific project or activity but is the net result of the diverse activities and phases of the projects within the program.

The FY 1981 program, in general, is designed to deepen the penetration of previously demonstrated new technologies by stressing the completion of previously initiated projects.

Strategy

The potential for energy conservation in the industrial sector is quite high. The sector consumes an estimated 38 percent of all the energy in the United States and most industrial processes are still energy inefficient. This inefficiency is due primarily to the development of the existing industrial infrastructure during several decades of abundant and low cost energy. The diversity of energy using processes and equipment suggests that an effective conservation effort must be tailored to the specific requirements of individual industries.

Historically, industry has gradually increased the energy efficiency of its equipment and processes. In response to higher energy prices and a greater risk of supply interruptions, this trend of improved industrial energy efficiency has increased in recent years. Even with these most recent efficiency improvements, however, there remain significant opportunities for major energy savings.

As in the buildings sector, the opportunity for energy savings lies both with the more wide-spread and effective implementation of existing energy technologies and the accelerated introduction of new, more advanced technologies. Because industry generally has easier access to the financing required for major conservation investments and direct Federal regulation of industrial energy efficiency does not now appear warranted (or technically feasible), the emphasis of the Federal strategy has been placed on information programs and RD&D. The FY 1981 budget reflects this emphasis and places particular priority on the development of those technologies having the highest energy savings potential in the near and mid term. Continued support for all of the program categories, however, is essential.

Accomplishments and Objectives

During FY 1979 and the beginning FY 1980, the Industrial Programs Office had several notable accomplishments, including;

- An additional two installations of the fume-burning coil coating curing system bringing the total systems on-line to fourteen;
- An additional five foam finishing installations were brought on line, for a total of fourteen in the textiles industries in the Southeast;
- Completion of prototype testing of a high efficiency slot forge furnance in Maine;
- Establishing advanced topping cycle cogeneration demonstration projects in four industrial applications, including textiles, chemicals, food processing and metal fabricatation.

- Initiation of conversion of waste polypropylene to fuel oil in a full size demonstration by a petrochemical concern.

The objectives of the Industrial Programs Office for the remainder of 1980 include, among others:

- Sponsoring a total of 26 workshops and seminars on improved boiler operation techniques, cogeneration and high efficiency electric motors.

- Full scale industrial demonstrations of new technologies, including textile foam processing, improved slot forge furnaces, high temperature ceramic recuperators and plastic waste to fuel oil conversion;

- Initiation of contracts to develop an environmentally acceptable coke-making process;

- Issuance of final reports to Congress on the feasibility of standards for electric motors and pump efficiency and applications of the second law of thermodynamics;

- Continued reporting on the progress of industry toward increasing energy efficiency and the use of recovered materials.

Industrial Programs Budget Summary

The FY 1981 budget request for the Industrial Programs Office falls under four specific subprogram areas.

The waste energy reduction subprogram supports the development of technologies which will permit efficiency improvements and fuel substitution in processes that are common to many industries. The FY 1981 budget request of 19.8 million for these activities is a 20 percent increase over FY 1980. Most of these funds are for the continuation of projects begun in earlier years. Completion of the ceramic recuperator demonstration and a number of one-time studies during FY 1980 are more than offset by increased funding for the demonstration and hardware phases of industrial heat pumps. Fluidized bed boilers, tube oil rerefining and water-to-water heat pumps.

The FY 1981 request of $20 million for industrial process efficiency is about 3 percent lower than the budget authority available in FY 1980. These funds support the research and development of process-specific technologies, with applications in the most energy-intensive industries, including steel, aluminum, paper, textiles, agriculture and food processes. Efforts are underway to determine technologies suitable for Federal support in the chemical and petroleum refining industries. During FY 1981, activities will include testing of commericial-size aluminum reduction cells, and demonstrations of mechanical dewatering of paper, efficient motors and crop drying systems. The request reflects the FY 1980 completion of several one-time studies and the slot forge deployment and analysis, and significant funding increases to support the hardware phases of ongong R,D&D projects. It does not include follow-on funding for the formcoke demonstration project which was funded by Congressional add-ons to the FY 1980 budget. This is because the evaluation, design analyses and process testing have not been completed and are expected to continue into FY 1981 after which the results must be carefully reviewed prior to a decision on continuation.

During FY 1981, the Industrial Programs Office will continue to support a broad spectrum of activities designed to further develop and commercialize industrial cogeneration systems. The budget request includes $12 million for this purpose, a 5-percent increase over FY 1980 levels. Emphasis will continue to be placed on cogeneration systems that minimized oil and gas consumption, including fabrication of a multi-fuel diesel topping system and installation of an advanced coal-fired, high back pressure steam system. Again, funding decreases resulting from the completion of one-time studies during FY 1980 are more than offset by the increased funding for hardware design, fabrication and installation of cogeneration projects begun in earlier years.

The FY 1981 request of $4.5 million for implementation and deployment is a $5.3 million decrease from the FY 1980 level. The activity supported includes the industrial reporting program, analytical support to program-wide project selection, as well as a range of information dissemination activities. The major reasons for the decreased funding requested in FY 1981 are completion of Congressionally mandated studies and several industry-specific implementation plans.

TRANSPORTATION PROGRAMS OFFICE

The President's FY 1981 budget provides $113 million for DOE's Office of Transportation Program, a reduction of $3.4 million from the budget authority available in FY 1980.

Strategy

The transportation sector, while accounting for only 26 percent of U.S. energy demand, consumes 53.7 percent of the nation's supplies of petroleum products. Use of trucks and cars alone accounts for about 40 percent of U.S. petroleum requirements.

During the next 10 years, the major opportunities for energy savings lie in further improvements to the fuel economy of new cars and trucks and the more efficient use of the existing transportation systems, including greater use of ridesharing and public transit, improved car maintenance and more fuel efficient driving techniques.

For the long term, however, it is essential that the nation's transportation system move away form its heavy dependence on petroleum products through the introduction of vehicles capable of using a variety of alternative energy sources, including electricity, even more efficiently. Because this longer term transition requires basic changes in the technology and structure of today's transportation system, it is critical that we continue efforts designed to support and accelerate this transition.

Programs directed at achieving both these near and long term objectives are being implemented by DOE in close coordination with the Department of Transportation and other Federal agencies.

Accomplishments and Objectives

During FY 1979 and first quarter of FY 1980 the major accomplishments of the Transportation Programs office included:

- A gas turbine engine containing ceramic turbine nozzle vanes and heat exchangers successfully completed 4,700 miles of road testing in a truck application.
- Pilot testing was completed and regular revenue service began on a turbocompound diesel heavy duty truck engine. Potential fuel savings are on the order of 8 percent.

- The road and track testing of a prototype organic Rankine bottoming cycle for heavy duty trucks is underway. The fuel economy improvement expected approaches 15 percent.

- In alternative fuels R&D, five automobiles were modified and tested for use of straight alcohol to demonstrate three competing fuel management systems.

During the remainder of calendar year 1980, the Transportation Programs Office has established a number of objectives, including, among others, the following:

- Begin development of 2 gas turbine concepts, with ceramic components, for passenger cars, which have the potential to increase fuel economy by 30 percent, meet stringent emission standards, and burn a wide variety of fuels.

- Completion of initial testing of the Stirling engine vehicle and initiation of commercialization planning.

- Addition of 350 vehicles to the electric vehicle demonstration; testing and evaluation of 2 prototype electric vehicles designed from the ground up.

- Initiation of controlled tests of the long term effects of gasohol and initiate engine tests of new lubricants and synfuel blends; and

- By mid-summer, place in revenue service in Baltimore five gas turbine buses with ceramic components.

Transportation Program Budget Summary

The $113 million budget for the Office of Transportation Programs is divided into four categories, plus program support. Vehicle propulsion R,D&D accounts for $55.9 million of the total FY 1981 request for this office. DOE's support of gas turbines will continue to place major emphasis on the development of ceramic materials and improved aerodynamic performance. The FY 1981 request will also support continued development of the Stirling engine commercialization effort, and completion of the diesel and alernative fuel phases of the urban gas turbine demonstration.

The $42.1 million request for electric and hybrid vehicle R,D and D will support the addition of 350 vehicles to the demonstration program, completion of the Near-Term Electric Test Vechicle testing and evaluation, loan guarantees for manufacturers, as well as a number of supporting analytical and developmental projects. This request continues the efforts in product improvement and near-term battery development by shifting a portion of this effort to Energy Storage Systems and increases support for advanced hybrid propulsion subsystems, continuously variable transmissions and commercialization activity.

The $6.7 million request for transportation systems utilization remains unchanged from FY 1980. This program area develops and distributes information on fuel economy and energy conserving operation and maintenance techniques.

The alternative fuel utilization program is budgeted at $5.3 million for FY 1981, also unchanged from FY 1980. The major emphasis of earlier years on alcohol fuels will be continued in FY 1981 to support extensive reliability testing and associated development activities. In parallel, minor efforts on synfuels and hydrogen will be phased out in FY 1981.

ADVANCED CONSERVATION TECHNOLOGIES

Under the new organization for the Office of Conservation and Solar Energy, there is created an Office of Advanced Conservation Technologies. This office will focus on the research, and development of conservation technologies which have applications across all end-use sectors and which require far reaching technological development. This office will combine the functions of the existing Energy Storage Systems program and new activity involving the support of advanced conversion and utilization technology.

ENERGY STORAGE SYSTEM

The FY 1981 budget request provides $71.8 million for Energy Storage Systems, and increase of about 8 percent over the FY 1980 budget. During the past year, this program office was transferred to the Office of the Assistant Secretary for Conservation and Solar Energy and now is under my direction. The major increase in budget authority is in near-term battery development.

Strategy

The goal of Energy Storage Systems is to develop and demonstrate reliable, low cost, safe and environmentally acceptable energy storage systems for use in the buildings, industry, transportation and utility sectors. Unlike the programs discussed above, Energy Storage Systems is designed to support the development of a group of similar technologies which have applications in all sectors. Consequently, the research, development and demonstration activities of the office must be closely coordinated with the sector-specific programs which utilize storage technologies.

Improved storage systems are an essential component to the achievement of several national energy objectives, including increased reliance on solar energy, the displacement of oil and gas by electricity generated from other fuels, and the recovery and productive use of waste heat. Storage systems permit intermittent energy sources such as direct solar and wind energy, to provide continuous service. They permit coal and nuclear powerplants to provide a greater share of peak electricity demand by storing energy generated during off-peak hours. Finally, they permit the more flexible use of electricity through improved battery development.

Since the different applications of storage technology require different amounts and types of energy to be stored for various duty cycles, several energy storage technologies are needed. The major thrusts of the strategy are to develop:

- For electric and hybrid vehicles--improved propulsion batteries and flywheel regenerative braking systems;

- For heating and cooling buildings--aquifer storage of hot and cold water for seasonal applications, phase change thermal storage for daily cycling applications, and phase change and chemical heat pump storage for solar applications.

- For solar conventional electric utility applications--batteries, thermal, mechanical, magnetic and underground (compressed air, pumped hydro) storage for utility load leveling and for use in solar electric systems.

- For industrial and multi-purpose uses--energy saving electrochemical processes, retrofit thermal storage for industrial heat recovery, and economical processes for producing hydrogen.

These strategies have been translated into quantitative performance and cost objectives for each technology under development. The approach being used to attain these objectives includes:

- Federal support of research and development in high-risk areas where the private sector is unwilling or unable to invest.

- Joint support of research and development when developmental risks have been reduced sufficiently that industry is willing to share the cost.

- Transfer of Federal information to private industry when the point is reached where the private sector will assume full responsibility and proceed with commercialization of the technology.

Accomplishments and Objectives

During the past year, industry has cost-shared energy storage R&D by matching almost 30 percent of the total DOE support. The DOE-funded R&D activities are being carried out by industry (49 percent), national laboratories (33 percent), other government agencies (14 percent), and universities (4 percent). Some examples of recent accomplishments include:

- For electric and hybrid vehicles: The first full size near-term electric vehicle battery cells (lead-acid, nickel/iron, and nickel/zinc) have been tested at the National Battery Test Laboratory (NBTL).
- For heating and cooling buildings: Field tests of sensible heat and cool storage systems have been conducted and second generation phase-change and chemical heat pump storage components have been laboratory tested.
- Three sites have been selected and preliminary designs for first generation underground pumped hydro and compressed air energy storage systems have been completed. The design for a 10 KWH super-conducting magnetic energy storage unit has been completed and hardware procured to begin construction for Bonneville Power Authority.

During the remainder of 1980, Energy Storage Systems expects to achieve the following objectives, among others:

- Complete fabrication of two batteries, zinc/chorine and nickel/iron, for vehicle on-road tests.
- Complete fabrication of full-size hydrogen electrolyzer for test as a special source of hydrogen for chemical use.
- Complete design of a waste heat storage system for sterilization processes in a food processing plant in North Carolina.
- Complete construction support for a zinc/chorine battery pilot plant in New York to produce 250 utility load-leveling batteries per year.

Energy Storage Systems Budget Summary

The FY 1981 budget for Energy Storage Systems is split into two major categories: Battery Storage; and Thermal and Mechanical Storage.

The $38.5 million budget request for the Battery Storage program area is a 17 percent increase over the FY 1980 level, with most of this increase being directed to near-term development of zinc/chlorine electric vehicle batteries and to acceleration of the capability and activity of the National Battery Test Laboratory. Increased support will also be provided for the development of dispersed, load leveling batteries for use in electric energy systems and the initiation of a third generation electric vehicle program to integrate advanced battery technologies with advanced electric vehicles.

The FY 1981 budget request for thermal and mechanical energy storage is $32.3 million, slightly greater than the budget authority available in FY 1980. The major shifts in subprogram emphases include increased support for the near-term development of underground mechanical storage systems and the elimination of funding for hydrogen storage, transport and use. The major emphasis of the program will continue to be the development, demonstration, and testing of thermal storage technologies for solar applications.

ENERGY CONVERSION TECHNOLOGY

The budget request provides $11 million to support more basic research and development of energy conversion technologies. This is a new activity to be initiated in FY 1981, although some support for research of advanced conversion technologies was previously supported by a former division of the Department, Energy Technology, and the Energy Research and Development Administration. Similar to the role of Energy Storage Systems, this program area will support technologies which have applications in all end-use sectors. Activities in the general areas of combustion, controls, materials processes and biochemical technologies are being considered. A research agenda is currently being developed in consultation with the academic and private sectors.

STATE AND LOCAL ASSISTANCE PROGRAMS

Under the new organization for the Office of Conservation and Solar Energy, the Deputy Assistant Secretary for Energy Assistance Programs will have responsibility for overseeing the Department's major grant programs for State and local governments, as well as for other institutions and individuals. These programs include the existing Institutional Buildings Grant Programs, the Weatherization Assistance Program for low-income households, the Small Scale Technology, and Inventors Programs, as well as the State and local grant programs to be funded under the still pending Energy Management Partnership Act. This area also will support the Department's responsibilities under Title II of the recently enacted Emergency Energy Conservation Act. In total, the FY 1981 budget request provides approximately $579 million for these efforts, an increase of approximately $121 million over the FY 1981 level.

The FY 1981 budget request provides $151.6 million to support grants to States and local governments under the President's proposed Energy Management and Partnership Act (EMPA). This is about $80 million more than the budget authority available in FY 1980 for the existing state grant programs authorized by EPCA and ECPA, the Energy Extension Service, and emergency conservation programs. The State activities supported by these existing programs, such as the Nationwide Energy Extension Service, will be extended by EMPA, which is intended to consolidate and strengthen State energy activities, rather than significantly redirecting them.

Finally, I would like to briefly discuss the Small Scale Technology and Inventors Program, which I believe is of particular interest to the subcommittee. The FY 1981 budget provides a total of $20.6 million for these programs.

The $14.8 million budget for the Appropriate Technology Small Grants Program is an increase of $2.2 million over the FY 1980 level. This program, established by P.L. 95-39 has provided over 600 grants of less than $50,000 each since its inception. The program is specifically designed to provide assistance to those individuals and small businesses which do not normally have access to Federal financial assistance. Funding is for research and demonstration of small scale technology projects promising to conserve nonrenewable fuels and to encourage the use of renewable energy sources such as solar, wind, water, and biomass. In FY 1979, the program was instituted nationwide and over 13,000 proposals were received. An example of the projects funded which have potentially significant nationwide benefits is an $11,000 grant to the University of Arizona to conduct workshops on how to build and install low cost solar hot water heaters. As of December 1979, over 1500 solar water heaters had been installed at a total cost to participating homeowners of less than $500 for each system. The increased funding for FY 1981 will be used to make 125 more grants and support efforts to encourage the more widespread application of small scale renewable technologies.

The Inventors Program established by P.L. 93-577, evaluates and provides assistance for promising energy related inventions. Using the expertise of the National Bureau of Standards, the program, since its inception, has evaluated over 12,000 inventions and the DOE has provided support for 68 of the inventions recommended. During FY 1981, the office plans to provide $2.4 million to NBS to support their efforts and to allocate $3.4 million to support an additional 40 grants for the development of recommended inventions.

In closing, let me reemphasize the importance of these programs to the achievement of our national energy objectives and the priority we place on their effective implementation. I would now be happy to respond to any questions you might have.

Senator CHURCH. Dr. Miller, do you have testimony you would like to give at this time?

STATEMENT OF DR. BENNETT MILLER, DEPUTY ASSISTANT SECRETARY FOR SOLAR ENERGY (DESIGNATE), DEPARTMENT OF ENERGY

Dr. MILLER. I do. I would like to submit the full statement for the record and summarize if for you, if that is appropriate.

Senator CHURCH. Very well.

Dr. MILLER. This afternoon we are going to describe to you the technology part of the solar budget and describe some of the highlights of our fiscal year 1980 program. It is a program that has made, I think, remarkable progress in the last year; I think the most important being that in every case we can state that these technologies are already well established in the sense that they work. There is no question of proving the feasibility of the systems. The question is only whether or not we can reduce the cost to the point where they can compete with alternative systems.

I would like to move very briefly through the items in the 1981 budget for you.

First, in the wind program, the program is aimed primarily at developing safe and reliable wind machines that can be used in a variety of locations. Our strategy has been to carry out development by industry through a sequence of wind turbines with increased performance and reliability and decreased expected production costs. I believe we are making rapid progress in this area.

In the small machine area, we have installed 1, 2, 8, and 40 kilowatt systems and have begun to install small commercially available machines around the United States to insure that some of the institutional problems, those associated with siting and interaction of the machines into utility grids are addressed.

We have three Mod OA intermediate scale systems rated at 200 kW, and a large 2 megawatt system, known as Mod 1. These are in operation now. By the end of 1980 we will be on line with the advanced 2.5 megawatt machine, Mod 2, system, and finally, we will install the final Mod OA intermediate machine in Hawaii.

A 300-foot diameter Mod 2 will produce twice the energy of the 200-foot Mod 1. It weighs almost exactly the same amount as the Mod 1. That is a major development because weight is cost; and the Mod 1 was very expensive because it was so heavy. We now have a system we think is within a factor of two of being commercially competitive on the grid.

In fiscal year 1981 we will continue to look at the development of more reliable lower cost systems. We will complete the initial design of the Mod 5, which we hope in terms of big machines will in some sense be the commercial prototype.

The intermediate scale program will center on the advanced multipurpose Mod 6. It is a program that will include both horizontal and vertical axis machines.

Finally, in the Mod 2 program, going back to that briefly, we will be in the process of installing a three-unit cluster of those on the BPA grid in order to test the tandem operation of several of these machines.

The wind program's budget for technology development has increased by $3.9 million to $16 million in fiscal year 1981. The principal activity here is at Rocky Flats. We will continue research in the area of blade development, blade materials, drive systems, and other components.

Funds for research and analysis are down about $1 million from fiscal year 1980. This small reduction is due to the completion of development of some computer modeling activities.

In the wind characteristics area we expect to complete and publish a National Wind Atlas by mid 1981. That program has been receiving excellent response from State and local governments.

I turn to a brief review of the solar thermal program. This program is developing basically three classes of systems, linear focusing systems, distributed receivers and point focusing systems, and central receiver systems. During fiscal year 1980 construction will continue on the 10 megawatt central receiver pilot plant. We expect that project to be completed at the end of calendar 1981.

There has been a cost growth attributable to the higher than anticipated inflation.

Twelve design studies, funded at the end of fiscal year 1979, will be completed this year for central receiver applications in utility prepowering and industrial retrofit applications.

It is interesting comment on some of the enthusiasm that we see outside of the Federal Government for this kind of program; that one of the studies rejected in the solicitation is being privately funded by the proposers. They came to us and asked if we would include them as part of the program. We negotiated a contract of $1 with them to make them part of the overall effort, even though they were not 1 of the originally selected 12. I think that says something for the enthusiasm of people on the outside.

In addition, we have begun construction on two side-by-side 500 kilowatt experiments in Almeria, Spain.

As part of our National Energy Agency activities the fiscal year 1980 funding request for the solar thermal program is $117.1 million, a decrease of $[illegible].5 million from fiscal year 1980. This decrease must be viewed in the context that almost $36 million in funds will be freed for use in fiscal year 1981 as a result of completion of funding authority for the Barstow project.

The $40 million from the solar applications appropriation will be devoted to industrial process heat systems that utilize this technology.

I would like to turn now to the ocean systems program. The major activity in fiscal year 1980 is the construction and operation of the sea-based facility that we call OTEC-1. It is scheduled to be deployed in June of this year and will test the key components, including the heat exchangers and the cold water pipe. A conceptual design of the modular pilot plant will begin this fiscal year 1980. This is basically a continuation of the 1980 effort. The budget request is $39 million, a $1 million reduction from the $40 million in the current fiscal year 1980 appropriation. However, those numbers can be somewhat misleading in that the first deployment of OTEC-1 will be completed in fiscal year 1980, freeing $15 million earmarked for that program. So we will have almost a $10 million increase in the operating budget in 1981 over 1980.

The key activity in the fiscal year 1981 budget is the conceptual design of an OTEC pilot plant. The initial concept is to build a 10 megawatt module to be part of a 40 megawatt system. Design will be initiated in the last quarter of 1980, and we hope to complete it in fiscal year 1981.

Turning now to the photovoltaic program, the basic thrust of that program is a strategy aimed at bringing system costs down to a competitive level in both distributed and stand-alone grid connected applications. The installed cost of photovoltaic systems has already decreased significantly from the $50 to $60 per peak watt in 1976 to $16 to $20 a peak watt in 1979.

We define competitive price goals for each of the application areas, a cost of $6 to $13 per peak watt for remote and international markets, $1.60 to $2.20 per peak watt for residential markets is expected by mid 1980, and $1.10 to $1.20 per peak watt to be achieved in the early 1990's. These numbers must be understood in the sense that those are the costs for the arrays and that these are the costs for the systems that include a component for the arrays and a component for the balance of systems.

There are currently a number of DOE-sponsored applications tests for photovoltaics, and I think the committee is aware of these, so in the interest of time I will not review them for you.

We have delivered to Congress the photovoltaics international plan called for in the Photovoltaics R. & D. Act and the report required by section 10A of that law which addresses Federal policies to promote photovoltaics.

The fiscal year 1981 budget request for the photovoltaics program is $140 million, and to this must be added $35 million from the solar applications appropriation, which is designed for essentially market oriented buys of photovoltaics under the FPUP appropriation and $30 million under a multiyear purchase strategy.

I would like to turn to the biomass program. It, in general, is directed at providing substitutes for imported liquid fuels. We recently set up an Office of Alcohol Fuels that reports to the Assistant Secretary through me, so I would like to break the discussion into those two components, a component basically related to the nonalcohol part of the program and that related to the alcohol part.

The budget request for biomass is $63 million. In 1981 this represents a $7 million increase over the fiscal year 1980 appropriation. There is, in addition, approximately $10 million in the solar applications budget devoted to wood commercialization. That market oriented work will be integrated into the biomass program in the new conservation and solar organization.

Of the $63 million, almost $17 million will be directly related to alcohol fuels line items, and I will come back to that later.

Besides the research development and demonstration funds, DOE expects to have moneys to bring biomass energy production capacity on line. The Department of Energy currently has appropriations for demonstration facilities in the form of the $2.2 billion Alternative Fuel Appropriation Act. Some portion of those funds will be committed to designing and building biomass energy facilities aimed at the production of alternative fuels, most notably ethanol.

The major increases in our biomass budget are in the area of research and exploratory development, the request going from $8.3 million in 1980 to $14.4 million. This represents our continued commitment to building a strong research program that can take advantage of some of the high risk projects with a potential of a significant effect in the long-term future of biomass.

We are increasing our work on advanced production techniques to $9.4 million. This includes our efforts in aquatic biomass and in hydrocarbon bearing plants.

I will make a brief survey for you of what we are doing in the alcohol fuels area.

Before doing that I would like to review our current understanding of some of the important issues surrounding the use of alcohol fuels.

First, the net production costs for ethanol, after credit for the sale of byproducts, are still higher than the price of unleaded gasoline. With existing Federal incentives the economics of ethanol production are favorable, however.

The second thing is that a number of States have taken action on their own initiative to suspend State excise taxes up to (9.5) cents per gallon, in addition to the 8.4 cents per gallon Federal exemption.

An issue that is important in any discussion of alcohol is the net energy balance problem. While this figure is highly dependent on the specific system being used and the heat source for the fermentation and distillation processes, studies have concluded that the net energy balance of systems is positive although small. The net energy question, in my opinion, while important, is oftentimes overworried. The generation of electricity is a net energy "loser." However, that does not mean that we stop generating electricity. We value the product highly and, therefore, pay energy penalties to get it. For ethanol we may be able to accept that to get fuel.

Senator CHURCH. I think that is the first time I have heard a Department representative make that concession. I have been waiting to hear that for 3 or 4 years.

Dr. MILLER. On the first day of spring, perhaps that is a good omen. I personally believe that. I don't think it was the Department that raised this issue of net energy balance in the way in which it has been raised. It has been raised by a number of the detractors of the ethanol production process but many things are net energy losers.

Senator CHURCH. What we need is liquid fuel to substitute for gasoline. We can take other forms of energy, even if it involves a net loss. You have just admitted that electricity, our favorite form of energy, involves energy loss to produce.

Senator MCCLURE. It loses two-thirds.

Senator CHURCH. Yes. It loses a good deal.

Dr. MILLER. Precisely right.

Senator CHURCH. A good deal more than alcohol.

I never have been able to understand the resistance to gasohol on the grounds that somehow it would take as much or maybe even a little more energy to produce. That has been a serious obstacle to progressing in this field, and it is irrelevant.

Dr. **Miller**. I agree with you. It is a red herring, just so long as you don't burn imported oil to make the alcohol.

Senator **Church**. We do not have to.

Dr. **Miller**. That is exactly right.

Senator **Church**. We take fuels we have to produce the alcohol that we need to reduce the oil imports presently creating such havoc on our economy and making us vulnerable to foreign blackmail. I never could understand why this did not have first priority, because your own Department admits that the only fuel available as an alternative to gasoline in the near-term in all probability is alcohol, and we can make it. We have the technology we need to make gasohol. All we lack is a program.

Dr. **Miller**. We are moving——

Senator **Church**. I want to know how you are moving. You get to that, because I will have further questions on that to see if you are moving the way grass grows.

Dr. **Miller**. Summarizing a few other of the issues besides the net energy balance and the cost issue which I have discussed, one issue oftentimes raised is the potential competition with food production and other traditional agricultural practices. We have concluded that using distressed crops and crops from marginal lands, excess crops and wastes, such as food-processing wastes, the bulk of the near-term alcohol production demand could be supplied without a negative impact on food production.

Finally, an issue of major interest to the consumer is the adaptability of ethanol for use in existing vehicles. Anyone stopping at a local gas station trying gasohol for the most part is satisfied that it is an acceptable substitute. There are some problems, such as minor impairments to drivability, but by and large it is an acceptable fuel, and I think is gaining consumer acceptance.

One area where the issue is not clear is on the use of ethanol in diesel engines, particularly on farms. There has to be a clear understanding of how ethanol would be used in diesel engines. We have begun a program in Bartlesville, one of our energy research centers, to help us answer that question and to begin to pin down some of the problems of converting diesel engines to use alcohol. I know of examples where they do, but in most cases you are dealing with a tinkerer who understands the engines and knows how to work the problem. We need to get a system that is easily adaptable without having a real mechanic available. I think that is going to happen.

The key issues are the questions of cost, and there I think we have to state that the cost of ethanol is higher than unleaded gasoline, the issue of food versus fuel which we feel is a manageable one, the issue of adaptability which is one in the process of being answered by the consumer himself.

The alcohol program that the Department of Energy is embarked on is an aggressive one. As you know, the President has proposed a very rapid increase in the production capacity of the United States for ethanol, quadrupling this year, and then an increase to 500 million gallons per year in 1981. That is a massive increase when one goes back as recently as a year ago and realizes that the ethanol production was probably only 40 million gallons a year. We are talking about an aggressive program to move alcohol fuels rapidly into consumption.

Senator CHURCH. Five hundred million gallons of ethanol may be big compared to 40 million gallons a year ago. I understand the present production is 60 million. That is miniscule compared to achieving a 10-percent alcohol blend of gasoline. That is about 11 billion gallons a year. You are talking about a big program which is less than 5 percent of what the country would require just to achieve a 10-percent mixture. Do you think that this falls far short of the necessary effort?

Why must we proceed with a goal that is less than 5 percent of what we know we are going to need if we are going to reduce gasoline and our oil imports by as little as 10 percent?

Dr. MILLER. I think there are two answers to that, Mr. Chairman. The first has to do with whether the resource exists to meet a 10 percent overall availability. If we wanted to achieve 11 billion gallons of ethanol, we would have to put into production as many acres as there are presently in production. If we were going to use food crops——

Senator CHURCH. Let us look at that, because I will not accept that answer. If you set aside land that we the taxpayers are, through the Government, paying the farmers not to use, the figures I have seen show we could produce 2 billion gallons of alcohol. That is 2 billion gallons, four times the size of your program, just from the land we are paying the farmers not to use.

Now, that does not take into account the many other sources for alcohol. We do not have to depend upon crops exclusively. We have wood wastes, we have other biomass including garbage. We have all kinds of resources we can look to for alcohol if we just use our imagination and lift our sights.

I do not know of anything that is more frustrating to me than trying to get the Department of Energy going on an alcohol fuel program. You come here now, after 3 years of agitation, with a program that falls so far short of the needs that it makes me think you are still not taking gasohol seriously.

I think the Department of Energy is mesmerized with the idea of vast technology or multibillion dollar plants we are going to build to convert coal into liquid fuel. None of that is going to come on line, even if successful, in quantities that count before the turn of the century. What are we going to do in the meantime?

This year we have diverted from sale to the Soviet Union, for foreign policy objectives, enough grain to make 2 billion gallons worth of alcohol. What is the Government doing? Why is that not held for feedstock for alcohol as we get these plants built? Why does the Department not grab hold of that grain? We have all kinds of sugar that we are storing. We are paying rental on the storage and the sugar is going to waste. Sugar is another good feedstock.

I think you are moving much too modestly in this field. I think the Congress has tried its best to prod you along with money. We have a new alcohol program in the energy package that is very generous in the money it makes available, but you do not seem to get your sights up.

I would not come here to brag on a program that is going to produce 500 million gallons in 1982. I think that is an admission of your inability to move on one front that could get us results.

Sometimes I think the Department of Energy is a failure because it is spread all over the map trying to do everything at once and, therefore, getting nothing much done. Here is a place where we could make great progress. We do not have to worry about the technology. We know how to do it. The economics are getting right. I even found a gas station in my neighborhood where I can get gasohol. People are not worried about the cost differential. The unleaded regular is $1.20 a gallon. They are selling gasohol for $1.23 a gallon, and people are buying it, all they can get.

Senator **Bumpers**. I would like to say that if we get that program it is not going to be because of the Department of Energy. It will be because of people, like a friend of mine, who borrowed $3 million a year ago to build an alcohol plant. He cranked up the plant a month ago and is making 9,000 gallons a day now from corn. He plans to make a profit on today's market of anywhere from 20 to 30 cents a gallon. He can only do that so long as the State and Federal Governments exempt gasohol from the highway tax. It is a magnificent plant, modern as tomorrow. He hired an engineer, built the plant, borrowed every penny, and did not ask DOE or the Government for a penny.

That is happening in two places in my State. I have a feeling it is happening all over the country. I do not know why we need DOE to start an alcohol program.

Senator **Church**. In every part of Idaho I have visited people have come to me, who were interested, and had feasibility studies and engineering studies on how to build alcohol plants. Many of them are combining cattle feed operations and natural hot water. They are ready to go. They cannot get any money, they cannot get loans. They come appeal to me to find out where they can get the capital to move ahead with building alcohol plants.

Was it 2 years ago that we passed a proposition that the Government ought to try to use gasohol in its own vehicles, as a starting place?

Senator **McClure**. Yes.

Senator **Church**. From what I am told, that program is not off the ground yet.

Dr. **Miller**. It is in the Department of Energy.

Senator **Church**. In the Department of Energy?

Dr. **Miller**. Yes.

Senator **Church**. To what degree?

Dr. **Miller**. We are trying to convert a fair number——

Senator **Church**. A fair number being?

Dr. **Miller**. I don't know precisely the number. You have to have the alcohol available, and it is a nationwide program, but we are going to try to convert as many cars as we can to operate on gasohol.

Senator **McClure**. You don't have to convert to operate on gasohol.

Dr. **Miller**. To use gasohol.

Senator **Church**. What about the other departments of the Government? What about the military?

Dr. MILLER. We are encouraging that to happen.

Senator CHURCH. Is it happening?

Dr. MILLER. I don't know, sir.

Senator CHURCH. Well, that is it. You should know. If there were any real priority attached to this program, you would know.

Dr. MILLER. I think it is a relatively new program for us, and we are trying very hard to move it forward rapidly. Generally we feel that the .40 cents a gallon excise tax exemption is going to promote the early introduction of existing technology; that the availability of a $2 billion dollar alternative fuels act appropriation is going to further make available funds——

Senator CHURCH. We have had the .40 cent exemption for the last 18 months. We have just continued to extend it in this new windfall profit tax bill. We have had that inducement, so far as the Federal inducement goes, for 18 months now.

Senator BUMPERS. I can take you to some mountain people in Arkansas that can give you a lot of technology on how to make alcohol on or off the farm. I do not understand this project with the TVA to demonstrate small farm technology when there are two or three industries in the country making modern small stills and selling to farmers right now.

Dr. MILLER. We have been concerned, Senator, regarding quality control in some of those systems and in the promotion of some of those systems that may end up with people buying pigs in pokes. As a result, at TVA and at the Idaho National Engineering Laboratory we are trying to put together well designed systems that we can then provide in the way of a prototype and say, we know this one works, we know it will give an output you can rely on.

There is no question people can produce alcohol. They have for a long time. But whether they can produce fuel-grade alcohol of a quality that is going to be acceptable is another question. If they are done on a scale you suggested, this individual has gone ahead with earlier, I suspect that would be a fine product, but some of the smaller systems may not be, and we certainly don't want to work on something which ends up with people getting a black eye, so we are trying to get good, solid designs.

Senator CHURCH. Let me ask a few questions about that project. I recently visited the College of Southern Idaho, where I was shown a project they have undertaken on their own initiative. It is about the size that an average-sized solvent farm could purchase, enabling the farmer to produce the amount of fuel required for the operation of his farm. It is within the reach of the farmer; that is, it is not too expensive for the farmer to install. They also hope to link it up with a very interesting windmill, a nondirectional type of windmill where the kinetic energy creates the heat by friction so that the alcohol is produced by friction and not by imported oil or any other fuel.

They are putting it together now, and all of their tests indicate it is going to work. They are in the process of putting up a windmill to see if that windmill will produce the kinetic energy necessary for the alcohol distillation. That seems to me to be a very practical project, worked on by very practical people.

The DOE field office in Idaho Falls, according to your testimony, will develop a design to test a 150,000-gallon-per-year ethanol plant, and subsequently will make detailed design information available to the public. What would a 150,000-gallon-per-year ethanol plant cost?

Dr. **Miller**. At present estimates, it ought to cost somewhere between $200,000 and $300,000.

Senator **Church**. First of all, it is not big enough to be commercial.

Dr. **Miller**. It should be big enough——

Senator **Church**. And it is too big and too expensive for a farmer, to build and install. So what is its purpose?

Dr. **Miller**. To try to get a nominally farm-sized system doesn't mean an individual farm, but it may mean several farms together in a cooperative that can produce fuel-grade alcohol. We believe that one of the difficulties that will be encountered with very small units will be the production of fuel-grade alcohol; in other words absolutely water free. If it is used directly on the farm these small units may be all right, but if they are going to put that into the distribution chain, even outside the farm, it has to be anhydrous, it has to be water free.

This is about the smallest scale system that we could think of which would be capable of making that fuel-grade ethanol, and it would not be a single-farm size, but it might be four or five reasonably good sized farms in the Midwest, for example. And you have to start some place.

Senator **Church**. Have you ever tried to get farmers to cooperate, four or five of them, to share a single facility? Have you every noticed how reluctant they are to share a tractor or a harvest machine?

Will you do something for me? Will you contact Dr. Taylor, president of the College of Southern Idaho, and send somebody out just to take a look at what they are doing?

[The requested information follows:]

Mr. E. Stevens Potts, Acting Director of the Office of Alcohol Fuels, spoke recently with both Dr. Jim Taylor, President of the College of Southern Idaho, and Senator Frank Church on Dr. Taylor's alternate energy project. Arrangements are now being made to send a Department of Energy representative to the College of Southern Idaho within two weeks to continue the discussion on this subject.

Dr. **Miller**. We, in fact, are supporting a program there aimed at complementing what they are doing in the laboratory; that is, to set up a curriculum to enable them not only to teach others what they are doing, but also to serve as a model for that area.

Senator **Church**. That is fine, but I wish you would go to look at that system once they have the windmill operational. Take a good look at it, because it seems to me to be a far more practical approach—the dimensions, the cost, and the possibility that farmers could install equipment of that kind to produce alcohol on the farm seems to me to make it very appealing.

The college of Southern Idaho has to experiment with this concept to determine over a course of time how it holds up, and what quality of alcohol is being produced. I would like you to follow this experiment, to see if it proves as successful as it now promises to be. If it does, we have something that could be far more helpful on the farm than this 150,000-gallon, $250,000 plant you are going to design.

I am glad you are going to design it. Maybe there will be a place for it. I am for anything that moves us in the direction of getting alcohol produced at this stage. I do not want you to stop doing something, even if it may not have as broad a practical use as a smaller and less costly plant. However, please look at this facility and any others that are small enough and cheap enough so that most farmers could install one. I know of no group that is going to be hurt worse from the spiraling price of fuel as the cost of foreign oil keeps climbing than the farmers, because of the amount of fuel they have to use. If they can install some kind of a facility on their own farm that they can rely upon for a good proportion if not all of their fuel, it would be a tremendous breakthrough.

Dr. **Miller**. I would be glad to, Senator.

Senator **Church**. Thank you.

Dr. **Miller**. I only have a few more comments on our alcohol fuel program before we turn to the questions and answers. I want to review what I think are the key elements of the administration's program to move alcohol fuels forward.

I think we have spoken a great deal about the excise tax exemption. We have added to that a production tax credit of the same amount, so if a farmer produces ethanol on-farm and uses it on-farm then he too would benefit from the exemption. It is the kind of equity we felt was extremely important.

There is a $3 billion Federal credit program proposed by the President to help people move into the productive capacity of the sort that we have been talking about. There is an Energy Security Corporation program for biomass of an additional billion dollars. There is a 10-percent additional tax credit proposed, that the research and development program at the agency supports. In all we believe that the gasohol program presently recommended would range between $8 and $12 billion for the period 1990.

We believe the 500-million-gallon-a-year goal between now and 1981 is a reasonable target. In order to implement this we have set up an Office of Alcohol Fuels. It is now in the process of being staffed. It has 15 people on board already. It is developing a program plan and is moving rapidly to take over all of the responsibilities in the Department for ethanol production.

And that, Mr. Chairman, I think concludes what I would like to say in the way of summary of what we are doing in the solar technology area, and we are certainly willing to answer questions.

[The prepared statement of Dr. Miller follows:]

Statement of Dr. Bennett Miller
Deputy Assistant Secretary for Solar Energy (Designate)
U.S. Department of Energy
Before the
Senate Energy Committee
Subcommittee on Energy Research and Development
March 20, 1980

I am pleased to appear before the Subcommittee on Energy Research and Development to present the research and development portion of the Department's FY 1981 budget request for solar energy. I am accompanied by Dr. Fred Morse, Director of the Office of Solar Applications for Buildings, Dr. Leslie Levine, Director of the Office of Solar Industrial Applications, Dr. Maurice Katz, Director of the Office of Solar Power Applications and Mr. Stevens Potts, Director of the Office of Alcohol Fuels. I would also like to introduce Dr. Robert San Martin who is the designated Deputy Assistant Secretary for Field Operations and International Programs. Dr. San Martin has been assigned management responsibilities for the Solar Energy Research Institute, the Regional Solar Energy Centers, information and international programs.

The solar energy budget request has two components, a Solar Technology program and a Solar Applications program. The Solar Technology program is oriented toward research, development and demonstration of technologies which use direct solar energy such as photovoltaic and solar thermal systems and those which use indirect solar energy, such as wind, ocean and biomass energy. In all cases we have no doubt of the technical capability of such systems to produce usable energy. The thrust of each program is to reduce the cost of technology and develop reliable systems which can be used in diverse markets. In Solar Applications our research and development activities to reduce the cost of active, passive and agricultural and industrial process heat systems are contained in the Systems Development line item. The remaining portions of the Solar Applications budget include lines for Market Analysis, Market Development and Training, and Market Tests and Applications.

What I would like to do today is give you a very brief status report on each technology program, including those technologies supported by Systems Development; identify key thrusts of the FY 1981 program; and briefly discuss the important problems and barriers we face in each technology area.

Photovoltaics

We at DOE are excited about the progress and potential of the Photovoltaics Program. Photovoltaic systems offer the promise of a clean, reliable, environmentally acceptable source of electrical power. They are totally modular and can be scaled to power a wristwatch, a highway warning sign, a remote village, a grid-connected residence or a central electric power station. In order to address potential domestic and international markets, the program is attempting to reduce photovoltaics system costs to a competitive level in both distributed and centralized, stand-alone and grid-connected applications. Complementing this strategy is a program of activities aimed at resolving technical, institutional, environmental and social issues related to widespread adoption of photovoltaic energy systems.

This past year has been one of extraordinary progress in the photovoltaics area. We have had major accomplishments in four program areas: (1) Cost reduction through Technology Development is achieved by identifying, developing and demonstrating cost-effective designs and production processes for technically feasible photovoltaic components in order to establish technology readiness; (2) Tests and Applications develop a body of experience, confidence and expertise within the private sector on the part of both users and suppliers of photovoltaic systems; (3) Advanced Research and Development investigates advanced photovoltaic concepts and brings the most promising ones to the point of technical feasibility; (4) effective management activities establish the program goals and assure their attainment through the guidance of program activities.

The FY 1981 budget request for the Photovoltaics Program is $175.2 million, of which $140 million is for the Solar Technology Program and $35.2 million is for the Solar Applications Program. The $140 million is a decrease of $7 million from FY 1980. Most of this decrease comes in the Test and Applications element of the program where the installation of the nine applications projects will have been completed. They will enter the operation and evaluation phase in FY 1981, and a limited number of residential and intermediate market experiments will be initiated. Another area of reduced funding is the Low-Cost Solar Array project. The FY 1981 funding of $33 million will be used to focus on specific flat plate approaches that can achieve the 70 cents per peak watt technology readiness goal in FY 1982. This is the next stage toward the commercial readiness goal set for 1986. By judiciously selecting to advance only the leading technologies, coupled with strong support of proprietary low-cost processes by industry, we are confident that the 1986 goal will be met, even with the decrease in funding.

In advanced research and development, the FY 1981 funding request of a $3 million increase over FY 1980, allows a continuation of our effort on pursuing advanced material and high risk research. We expect to demonstrate 10 percent thin film cell efficiency for at least three cell materials, as well as to continue exploration and development of a variety of advanced material technologies. The key thrust is to pick "winners" from the many options in the program and to concentrate our resources on those approaches with a high probability of meeting our 1990 goal.

In technology development, the emphasis continues on the two principal module technologies, flat-plate modules and concentrator subsystems. FY 1981 will see the completion of designs for automated module assemblies and prototype silicon sheet fabrication equipment. We will continue to narrow the funding to key areas with the highest probability of meeting the 1986 goals. The expanded balance-of-systems program will continue and will be the critical area for cost reduction in FY 1981.

We are also considering several options within this budget request for increasing U.S. silicon production in order to maintain the program plans and schedule without encountering a silicon shortage in the early to mid-1980's. A recent industrial survey by the Jet Propulsion Laboratory for DOE has found that the supply of polycrystalline material needed for making both semiconductor devices and solar cells will be quite tight from 1982 to 1985. The needs of the semiconductor industry will probably be met by the existing supply industry, but this will require expanded capacity and price increases from the current $64/kg up to $100/kg or higher. The program's planned price goals of $35/kg in 1982 and $14/kg in 1986 will likely not be met under current industry plans. The failure to meet these goals would be reflected in higher prices than the current DOE goals for the 1982-1986 period. We are currently considering several silicon supply options to maintain the schedule in our Program Plan.

Funds totaling $35.2 million of Solar Application's Market Test and Commercial Applications budget will be designated for photovoltaics, a major increase from the $10 million level in FY 1980. These funds will enable us to pursue the legislative mandate of PL 95-619, Part 4 (the Federal Photovoltaic Utilization Act). The program will expand the market test program from the Federal sector into the private sector in this country and internationally. Approximately $5 million of the funds requested will be used for the installation of 500 kW of electric generating capacity from photovoltaic systems under the Federal Photovoltaic Utilization Program (FPUP). Although FPUP market studies do show a 10-20 MW near-term potential for sales of photovoltaic systems within the Federal community, our assessments of private markets show much larger potential there (30-150 MW per year near-term). Therefore, DOE has decided to shift its emphasis from Federal markets to development of Federal, international and U.S. private markets. Accordingly, after extensive analysis we now propose a major initiative, the Multi-Year Purchase Program. This three year effort, with $30.2 million in FY 1981, should result by 1984 in proven market-ready systems for the principal photovoltaic markets of the mid-80's. The key markets we will address with RFP's from the program are Federal use, international, residential, industrial, commercial, and municipal energy systems. The final mix of applications will result from the quality of the proposals we receive. The capacity purchased depends on the cost of each application, the extent of cost sharing by industry, and the degree of design effort required. We have as a goal that 80 percent of the FY 1981 program budget be used to purchase hardware, and if the average DOE cost is $15/Wp and the cost sharing is 25 percent, then we could see purchases of 1.5 MW to 2.5 MW in FY 1981.

I believe that the accomplishments just described indicate clearly why we are pleased with the rate of progress in the Photovoltaic Energy Systems Program and are confident that its tough goals can be met if this rate can be continued.

Wind

The DOE Wind Program is aimed at developing safe, reliable wind machines which can be used economically in a wide variety of locations and applications. Our strategy in this area has been to carry out the development, by industry, of a sequence of wind turbines with increased performance and reliability and decreased expected production costs.

The bulk of the funding is in the Engineering Development area where we have requested $49 million - an increase of almost $15 million over our FY 1980 budget. These funds will provide for completion of 4 kW and 15 kW advanced small machines as well as completion of field testing and product improvement of 1, 8 and 40 kW machines, and initiation of some second generation machines of these sizes. Intermediate scale development activities will center on the Advanced Multi-Purpose Wind Turbine Program, MOD-6, as part of which both conventional horizontal as well as vertical axis (Darrieus) machines will be developed.

We have learned a great deal about mid-size machines in the past year from the testing of the first 200 kW MOD-OA's. The Clayton, New Mexico MOD-OA now has logged 6,000 hours of operation, more than any mid-size or large wind turbine extant, except the 1950 Danish Gedser machine. This experience alone with other results from the program lead us to expect a 50 to 70 percent reduction of cost per unit of energy of MOD-6 relative to costs of earlier machines.

The main emphasis for large machines will be in developing an advanced Multi-Megawatt Wind Turbine, MOD-5. As emphasized last year, we are planning to select two competing contractors in order to insure a healthy, competitive industry. In addition, the three-unit cluster of 2.5 MW MOD-2 wind turbines, to be located near Goldendale, Washington and operated on the Bonneville Power Administration grid, will be completed and testing will begin in FY 1981. Operational testing will also continue on the previously constructed 2 MW MOD-1 machine.

The wind program's budget request for Technology Development has increased by $3.9 million to $17.1 million in FY 1981. A principal activity in this area is the operation and maintenance of the small systems test center at Rocky Flats, Colorado. This center tests commercially available machines as well as federally-developed prototypes and supports the development of standards and ratings for small machines.

Funds for Research and Analysis activities are requested at a level of $7.7 million, reduced about $1 million from FY 1980. This small reduction is due to completion of the development of some computer modeling activity. Research and Analysis activities include market analysis, environmental impact studies, assessment of institutional barriers, and research into innovative wind systems.

In the Wind Characteristics area, we expect to complete and publish a National Wind Atlas by the middle of FY 1981. The $6.2 million request will provide for special wind resource assessments in areas that appear to have good winds but where uncertainty exists due to poor quality or missing data. The Field Evaluation Program, which through 1979 and 1980 has concentrated on about 35 states and territories, has been receiving excellent response from state and local governments. Overall, we are requesting $80 million for wind technology research, development and demonstration, a 26% increase over FY 1980.

Solar Thermal

Solar thermal systems have a wide-range of potential applications in industrial and utility markets. These range from large central utility plants and small community power systems of under 10 kWe, to agricultural and industrial process heat applications which can require temperatures of several hundred degrees Fahrenheit - up to 2500°F.

The program is developing three classes of systems that have the potential to capture major shares of the U.S. energy market. They are: linear focusing distributed receivers, which include parabolic troughs and hemispherical bowls; point focusing distributed receiver systems, also known as parabolic dishes; and central receiver systems, sometimes referred to as power towers.

The FY 1981 funding request for the Solar Thermal Program is $117.5 million, a decrease of $3.5 million from FY 1980, which must be viewed in the context that almost $36 million in funds will be freed up for use in FY 1981 as a result of the completion of the funding authority for the Barstow project. In addition, more than $40 million from the Solar Applications appropriation will be devoted to agricultural and industrial process heat systems that utilize solar thermal technology. The budget request also shows increases in the distributed receiver and advanced technology programs.

We are requesting $37.25 million for the Central Receiver Program. This is a decrease of $27.75 million from FY 1980. This change is primarily associated with the near completion of funding authority for the Barstow pilot plant which will answer the key questions about the feasibility of the central receiver system. This development of central receivers for utility repowering and industrial process heat retrofits will continue through FY 1981.

The Distributed Receiver Program request is $46.25 million, an increase of $12.25 million from FY 1980. This includes continued operation and improved collectors for the irrigation pumping system in Coolidge, Arizona, completion of the Almeria, Spain, 500 kWe trough system, construction of line-focuing modular industrial retrofit experiments and development of advanced generation systems. In the point-focusing systems (dishes) area, projects in the small community area include the 400 kWe industrial total energy project in Shenandoah, Georgia, and a 1 MWe small community experiment at a site to be determined.

The Advanced Technology Program has requested $34 million in FY 1981, an increase of $12 million over FY 1980. The thrust in this area is to support development of thermal technology and materials necessary to expand the market potential for solar thermal to higher temperature heat and fuel production systems. For example, in FY 1981, some of the R&D is for thinner, more reflective glasses for heliostats, plastics for concentrator enclosures, new absorber materials, ceramics for high temperature systems as well as a wide-range of other exploratory thermal engineering research.

Ocean Systems

The FY 1981 program is basically a continuation of the FY 1980 program. The budget request is $39 million, a $1 million reduction from $40 million in the current FY 1980 appropriation; however, it must be recognized that with the first deployment of OTEC-1 in FY 1980, almost $10 million in operating funds will be freed up in FY 1981 to pursue other program objectives. Thus, the operating budget that supports the overall program increases from $28.6 million to $38.3 million. FY 1981 activities will generate information on such ocean systems as the sea-based OTEC-1 and the Seacoast Test Facilities and other test platforms. OTEC-1 will complete its first heat exchanger tests during FY 1981, will be brought back to port for the installation of advanced heat exchangers and will then be redeployed in late FY 1981 or early FY 1982.

A key activity in FY 1981 is the conceptual design of an OTEC pilot plant. The initial concept of this plant is to build a 10 MW module which would be part of a 40 MW system. Design will be initiated in the last quarter of FY 1980 and will be completed in FY 1981. If results from OTEC-1 and other tests are encouraging and a decision is made to build an OTEC pilot plant, it is anticipated that detailed design and construction can be started in FY 1982 and completed in FY 1985. This pilot plant would be of a scale sufficient to demonstrate the performance and reliability of both the total system as well as the individual components. Operational results could provide enough information for a decision on whether to build a commercial size facility.

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The Advanced Research and Development program element will continue work on both open and closed cycle OTEC systems with emphasis on developing advanced heat exchangers. Studies will continue on systems that employ ocean currents, waves and salinity gradients as energy sources. However, until there are indications that technical and economic feasibility for such systems are achievable, these activities will continue at a low level. The requested funding in FY 1981 for advanced research and development is $3.5 million, essentially constant from 1980.

Biomass

Biomass has significant potential as a substitute for imported liquid fuels and other uses. The DOE Biomass Program is directed at this potential. The budget request for biomass in FY 1981 is $63 million which represents a $7 million increase over the FY 1980 appropriation. There are several points to be made regarding this number. First, there is approximately $9 million in the Solar Applications budget devoted to wood commercialization. The market-oriented work will be integrated into the biomass program in the new Conservation and Solar Energy organization. Second, of the $63 million, some $14.6 million can be directly related to alcohol fuels (discussed below).

The Department of Energy currently has appropriations for demonstration facilities in the form of the $2.2 billion Alternative Fuel Appropriation Act. Some portion of those funds will be committed to designing and building biomass energy facilities.

We are actively working with other elements of the department to ensure that the monies of that Act serve to demonstrate the viability of a range of biomass conversion approaches. Moreover, the Departments of Agriculture and Commerce have significant programs in the Biomass area. In FY 1981 these two agencies are expecting to issue loans and loan guarantees totaling $155 million for Biomass facilities.

We are currently trying to re-evaluate our ongoing RD&D activities to ensure that they adequately support the near-term goals of this legislation. Thus, for example, the Technology Support line of the biomass budget request is $6 million above the FY 1980 appropriation. We have identified those monies as increasing support for near-term R&D in the areas of fermentation, anaerobic digestion and direct combustion of biomass. We have also increased the Support and Other line in the budget request from $1.5 million to $3.5 million to provide for additional environmental research related to the production, harvesting and conversion of biomass.

The other major increase in our biomass budget is in the area of Research and Exploratory Development where the request has gone from $8.3 million in FY 1980 to $14.4 million. This represents our continued commitment to building a strong research program that can take advantage of some of the high risk projects with potential for significantly effecting the long-term future of biomass. In particular, we are increasing our work on advanced production techniques to $9.4 million. This includes our efforts in aquatic biomass and in hydrocarbon-bearing plants. We have

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reduced our request for the Production Systems and Conversion Systems lines by $7.1 million. In large part, this represents a transfer of activities to the Technology Support line for near-term programs, particularly low Btu gasification.

An Office of Alcohol Fuels has recently been established in the Office of Conservation and Solar Energy under the direction of the Deputy Assistant Secretary for Solar Energy. The Biomass Energy Systems Program has until recently been the central focus for all biomass-derived alcohol research, development and demonstration activities for the Department. The Office of Alcohol Fuels, working closely with the Biomass Program on their ongoing alcohol activities, will run the alcohol programs, plan new initiatives, and manage new programs as requested by Congress and the President.

The Office of Alcohol Fuels is managing a number of system demonstration and information dissemination activities. A project will be initiated shortly in cooperation with the Tennessee Valley Authority (TVA), to design, demonstrate and evaluate the operation of small scale stills on farms in the TVA region. Another project to be managed by the DOE field office in Idaho Falls will develop designs and test a 150,000 gallon per year ethanol plant and will subsequently make detailed design information available to the public.

The Office of Alcohol Fuels will also be responsible for evaluating and administering those portions of the Alternative Fuels Demonstrations Program (P.L. 96-126) applicable to ethanol production from biomass. Regulations are now being completed to distribute the

Program's $2.2 billion appropriation. The appropriation includes $100 million for feasibility studies, $100 million for cooperative agreements, $500 million for loan guarantees and $1.5 billion for purchase agreements. On February 25, a solicitation was sent out for feasibility studies and cooperative agreements. Sixty-days will be allowed for the publication response, and sixty-days for DOE to evaluate and announce contract awards. It is anticipated the loan guarantee money will be available later this spring. The share of money to be spent from the alternative fuels demonstration program on ethanol from biomass will be determined once responses to the solicitations have been evaluated. Public interest in this program, especially the Alcohol Fuels aspects, has been extremely high.

This Office is informing the public and interested investors on the production and use of alcohol fuels. On February 4, 1980, DOE designated the Solar Energy Research Institute as the National Alcohol Fuels Information Center. The center provides technical and financial information on the production of alcohol fuels. A toll free number, (800) 525-5555 is in operation for public inquiries.

The Office is also developing materials aimed at answering the most frequently asked questions regarding alcohol production. The principal document at present is the manual for small scale alcohol production entitled, "Fuel from Farms" developed by the Solar Energy Research Institute at DOE's request. Two-hundred-thousand copies are available for public distribution through the Technical Information Center at Oak Ridge, Tennessee.

We estimate that $11.6 million appropriated in FY 1980 for ethanol fuels in the Biomass Program and $14.6 million in the FY 1981 budget request will be used to support activities of the Office of Alcohol Fuels. These activities include information dissemination and technology development for on-farm stills, development of improved fermentable crops such as sweet sorghum, and research and development on fermentation.

A key to future capacity expansions and cost reductions in alcohol production is research and development on technologies to make alcohols. The Biomass Energy Systems Program has a comprehensive research and development program for ethanol production. Efforts are currently underway in FY 1980 to improve the process efficiency of existing fermentation systems and to expand the use of higher yield crops such as sweet sorghum. Investigations of production systems are using herbaceous species screening studies, specialized energy farming techniques, and studies of sugar cane and tropical grasses to improve yields. Conversion systems are also being developed to use relatively more abundant and less expensive lignocellulosic agricultural and forest residues to produce ethanol and methanol. When this technology becomes economical on a commercial scale, the food vs. fuel issue will be significantly diminished.

The Biomass Program and the Office of Alcohol Fuels are but one part of the Administration's actions to promote the use of Alcohol Fuels. Key elements of the President's program include the following:

o Permanent exemption for gasohol from the 4 cents per gallon federal gasoline excise tax

o Forty-cents per gallon production tax credit

o $3 billion federal credit program

o Energy Security Corporation programs for biomass

o Revision of the entitlements program

o 10% investment tax credit

o Using gasohol in federal vehicles

o Farm program management

o Alcohol production research and development

o 500 million gallon target

Research related to ethanol will also be underway in other sections of DOE in FY 1980 and FY 1981. A few of the key activities to be coordinated with the Office of Alcohol Fuels include:

o The Small Scale Appropriate Technology Program -- Provides grants of up to $40,000 to develop, demonstrate, and encourage the use of energy-related small scale technologies that use renewable resources, such as ethanol from Biomass.

o The Alternative Fuels Transportation Utilization Program -- Provides competitive awards in research, development and testing of alternative fuel uses in transportation systems. The DOE fleet testing program on gasohol and other alcohol fuels is part of this office. The aim is to develop technology to support reliability testing and demonstrate the use of straight alcohol fuels.

o The Urban Waste Program is an R&D program studying the conversion of urban and municipal waste products to energy including ethanol. This program will also participate in the Alternative Fuels Demonstration Program (P.L. 96-126).

International

The International Solar Program has become a separate line item this year, to cover existing agreements between the U.S. and foreign governments. This program will come under the direct supervision of the Deputy Assistant Secretary for Field Operations and International Programs, who is now responsible for this program element. During the last few years a number of multilateral and bilateral agreements have been negotiated in solar energy.

The FY 1981 request for Solar International activities is $15 million, $4 million of which is included under the Solar Applications appropriation. The present request will cover firm commitments for ongoing technology demonstration projects and bilateral agreements. The FY 1981 program will also integrate these activities with international activities formerly carried out under the Solar Applications division including assessments of international markets, information system support, trade promotion, and application demonstrations. This integration will allow the program to better manage its resources and avoid duplication or over-concentration of efforts in specific areas. The result will be a more effective program to make renewable energy supplies more available for international energy needs.

Systems Development for Solar Applications

In the Solar Applications budget, we are requesting $56 million for Systems Development an increase of $3 million from FY 1980.

Monies requested under this line item are for research and development which results in technically proven components, designs, and systems for market testing. The budget request focuses on three areas: $15 million for passive heating and cooling; $20 million for active heating and cooling; and $21 million for agricultural and industrial process heat.

The budget request for passive heating and cooling systems development is a key element of our overall effort to promote passive solar applications. There continues to be the need for selected research, data gathering and analysis, and engineering development work for certain passive products, prototype building designs, design tools for architects and builders, and the like. In addition, we have budgeted $2 million in this category for several pilot city and urban planning projects. I am particularly excited about this last area because it represents the first real commitment to udnerstanding the problems and potential of using solar systems in an urban environment. Seventy-five percent of our population live in urban areas. Solar must become an integral part of the urban energy equation. Last fall the solar program sponsored a 2-day workshop on this subject. We had people from every major public interest organization and every major organization interested in renewable energy. The message they sent was loud and clear. If we don't get solar in the cities, we won't get solar in the country. I share that view.

In the area of active heating and cooling systems development, funds are requested for research and development of residential and commercial solar heat pump and solar cooling systems of various designs.

Finally, a key element of our systems development work is the $8 million for continued development and testing of a dependable, mass-produceable line-focus solar collector. The ability to scale-up and mass-produce collectors for industrial uses is the key for solar making a significant impact in the industrial sector of the marketplace.

Field Management of the Solar Program

Finally, I would like to explain how we implement the solar program in the field. Much of the day-to-day program and project management has been assigned to operations offices, national laboratories including the Solar Energy Reserach Institute (SERI) and the Regional Solar Energy Centers and other Federal agencies in some cases. In the Solar Technology Program, SERI is a key participant. Besides being a central clearinghouse for much research and development data and solar information, SERI manages key research components in photovoltaics, wind, biomass, solar thermal, ocean systems and heating and cooling programs. A new laboratory and office facility is in the design stage. The budget request for construction in FY 1981 is $10 million.

This concludes my prepared statement. I would be happy to answer any questions about the program.

Senator BUMPERS. Dr. Miller, when do you plan to reach this 500 million gallon goal?

Dr. MILLER. The target is some time in 1981. I wish I could tell you precisely, but we can't. The uncertainties ultimately are ones that are dictated by the marketplace. We do believe we will have available lines of credit which will enable people to upgrade existing facilities, but how rapidly they move ultimately is a decision of their own, and we do think that it is double in calendar 1981, but precisely when, I just can't say.

Senator BUMPERS. Do you not have any gallons of ethanol you could produce from 13 million tons of corn?

Dr. MILLER. We could, but if we are talking about existing distillery capacity we still have to upgrade a fair amount of capacity.

Senator BUMPERS. I understand that. I am saying if we had the facilities to convert—it is 2.7 gallons per bushel of corn?

Dr. MILLER. One hundred gallons per ton.

Senator BUMPERS. That translates into what, then, 1,200 million gallons?

Dr. MILLER. About that. If you took all of that corn and converted it directly to ethanol, it would yield 1.5 billion gallons.

Senator BUMPERS. Do you know how many gallons of gasoline we consume a day in this country?

Dr. MILLER. 100 billion divided by 400. That is 250 million.

Senator BUMPERS. Incidentally, let me give you an easier way to figure that. Use 7 million as a rule of thumb. You use 7 million barrels a day and that translates into 304 million gallons. Isn't that easier, Dr. Miller?

Dr. MILLER. You know scientists have to do it in a roundabout way.

Senator BUMPERS. I was going to read a page of your testimony back to you and ask what it meant, but I am going to restrain myself and not do that.

Would you agree with me, as important as alcohol is in our future, that we have raised people's expectations about what the very maximum we can do in this country with alcohol is? We have certainly raised their expectations based on what we can do in the short term, even within the realm of possibility, until we get enough money in DOE to establish a good loan program.

Everybody in my State is waiting for the Department of Energy to say "Come and get it."

They do not need technology. You may say they are buying a pig in a poke, or the technology will not be good, or as good as it ought to be but, the way I perceive DOE now, they are going down the same way the Pentagon went for years. They never get around to doing anything because somebody has a more exotic plan on the board. We cannot buy planes because somebody else has a better one. Their imagination for those exotic, sophisticated weapons is unlimited. The Department of Energy cannot get around to doing anything.

We appropriated money every year since I have been in the Senate for that power tower in Barstow, Calif., and it is not under construction, is it?

Dr. MILLER. It is going under construction now.

Senator BUMPERS. When is now?

Dr. **Miller**. It will be done in December of 1981, which is a schedule we have had for well over a year.

Senator **Bumpers**. It will be completed in December 1981?

Dr. **Miller**. Yes.

Senator **Bumpers**. When are you going to start?

Dr. **Miller**. The land has been graded, and we are going for construction contracts now.

Senator **Bumpers**. I believe I heard that same testimony last year, not from you.

And, incidentally, the revolving chairs program at DOE is another problem. We never get the same people here. One of the excuses we hear is that we have just gotten this program in our organization, and we have reorganized this and that. There is no accountability. I hope you are there long enough to hold accountable for beginning of construction of that power tower in Barstow. I do not think it is a good concept. I am not hot on the idea because and I think small-scale technology will be more efficient. How much money have we appropriated so far for it?

Dr. **Miller**. We have an authorization of $108 million.

Senator **Bumpers**. It will take more than that, will it not?

Dr. **Miller**. We estimate $118 million, primarily to a higher than expected inflation rate.

I would argue with you, Senator, if I can. I think it is a good project.

Senator **Bumpers**. Do not be intimidated just because I am a great person; speak up. [Laughter.]

Dr. **Miller**. I agree with you we have to finish the things that we start, and we expect to finish Barstow. Although you haven't seen me too often before, I have been around hiding in the corners. I have followed Barstow since its inception. We are going to deliver on Barstow, and I think on schedule. I think you will have a project we can look to as a real accomplishment.

Senator **Bumpers**. Staff has handed me a note stating DOE has proposed to OMB that, as part of the new budget cuts, Barstow be canceled.

Dr. **Miller**. That is not true.

Senator **Bumpers**. I hope it is not. I want it built, and either fish or cut bait. I was excited about it when I first came to Congress. Somebody gave me a drawing and had a markup displayed on the table for everybody to study. In any event, I hope it will go forward.

Has the President proposed a 40 cent per gallon production tax credit for alcohol from biomass?

Dr. **Miller**. Yes.

Senator **Bumpers**. When?

Dr. **Miller**. In the package that went up when we announced the alcohol program. It was in there, or may have come subsequently, but it was an inclusion of a 40 percent production credit as well just to insure there was an equitable arrangement so that the farmer benefited from the same subsidies as people who were operating through the distribution chain.

Senator **Bumpers**. Tell me where we have biomass pilot projects or research projects going on in this country?

Dr. **Miller**. In alcohol or——

Senator **Bumpers**. In alcohol.

Dr. **Miller**. There are a number of relatively advanced technology processes we are looking at to take advantage not of existing resources but of other kinds of resources, most notably cellulose feedstocks. I understand your's and Senator Church's concerns, but our emphasis has been in the past on developing technology——

Senator **Bumpers**. I thought that was biomass loss, the conversion of cellulose products to alcohol.

Dr. **Miller**. No, sir.

Senator **Bumpers**. It is not?

Dr. **Miller**. No, sir, there are programs aimed at converting cellulose processes to low Btu gas and medium Btu gas, programs aimed at taking aquatic biomass, plants that grow in the ocean and converting them; programs aimed at taking noncellulose materials, like animal wastes, and converting those into high Btu gas. In fact, we have a very successful demonstration of that down in Florida, where we are producing so much gas that the individual had to find places to sell it. It was just remarkably successful.

Senator **Bumpers**. Well, if it is so successful why would that not be a great thing for the feedlot operators in Kansas and Colorado to do?

Dr. **Miller**. It is. USDA is underwriting a loan for the building of that kind of system out in Colorado.

Senator **Bumpers**. You started your testimony today saying that—did you say that the production of methanol is still not price feasible?

Dr. **Miller**. No; ethanol.

Senator **Bumpers**. You said ethanol, not methanol?

Dr. **Miller**. Yes.

Senator **Bumpers**. How can this person in Arkansas make money on it if it is not feasible? He is planning on making a bundle and amortizing a $3 million loan.

Dr. **Miller**. I said the cost of ethanol today is not strictly competitive with unleaded gasoline. However, with the Federal excise tax exemption and with some State excise tax exemption it is competitive, particularly in States with high excise taxes that are rebating those as well. I am delighted to hear that the individual was able to get a loan. It has been our position that, in fact, with the excise tax exemption people ought to be able to get loans. We know many have not been able to, and that is the reason for the $2.2 billion loan guarantee program that will be initiated within the next few days. It is to provide the wherewithal so that some of the more timid lenders will get into the business. That was an Interior appropriation Public Law 96-126, made available to the Department of Energy for $2.2 billion for all alternative fuels.

Senator **Bumpers**. You have that in hand?

Dr. **Miller**. In hand——

Senator **Bumpers**. For what are you waiting?

Dr. **Miller**. We are not waiting for anything. We got the appropriation in November. We have already issued solicitations for $200 million worth of feasibility studies and cooperative agreements. We have final versions of the draft regulations on the loan guarantee portion of that almost completed. We expect to issue it within the next month and a half or so. We are moving very rapidly.

Senator **Bumpers**. What are these hearings you are holding in Washington, March 25, inviting everybody that is interested in alcohol production to come to Washington to file applications, and you will answer their questions?

Dr. **Miller**. We just had a meeting yesterday or the day before that was part of the feasibility studies on which we issued a solicitation. That is for the $200 million worth of support and feasibility studies—feasibility studies and cooperative agreements for alternative fuel systems. We anticipated a very large turnout of people who would be interested in that solicitation from the point of view of ethanol production; and, in fact, that is exactly what happened.

Senator **Bumpers**. Did you have a big crowd?

Dr. **Miller**. Enormous; 1,300.

Senator **Bumpers**. And you only had room for what, 1,200?

Dr. **Miller**. I don't know. It is the biggest auditorium I know of in the area.

Senator **Bumpers**. You told me you had seating for 1,200 and I was afraid there would be that many here from Arkansas. I suggested to DOE that you repeat that on a regional basis.

Dr. **Savitz**. I think one more is going to be held in the Midwest in another 2 weeks.

Senator **Bumpers**. What does the Midwest have that the South does not have?

Dr. **Savitz**. No difference.

Senator **Bumpers**. Do you have the money and resources to have one in the South, too?

Dr. **Savitz**. We have to look into that. Our travel is getting constrained with the budget-cutting exercise that is going on.

Senators **Bumpers**. How many people do you have in your biomass program?

Dr. **Miller**. Right now, seven.

Senator **Bumpers**. That is five more than you had at the beginning of the year?

Dr. **Miller**. Yes; we are going to 11 within the next month or so. You have to understand, Senator, that we have formed the alcohol fuels program out of that. Last year at this time there were two people in biomass. We brought that up to six. Then when the alcohol fuels program started we took three of those people and put them in the alcohol fuels side. We have the alcohol fuels program up to 15, and the biomass program back up to 7, depending on how you count part-time help, 7 or 8, and we will have that up to 11. I think we are really making an effort.

Senator **Bumpers**. I am not here to champion the cause of hiring more people. It would seem you were not serious when you started out with two people to administer a $2.2 million program. I like the idea, if you can do it.

Let us go to photovoltaics for a minute. Tell me, in the current state of the art, what is the cost per watt of photovoltaics?

Dr. **Miller**. The best cost data we have right now is based on the recent awards we made. They were like June of last year.

Senator **Bumpers**. Was that Mississippi County Community College in Arkansas?

Dr. **Miller**. No, sir. That one has been going on much longer. These were the most recent awards that we made, and the costs were between $17 and $30 a watt, for a total system. That is the best data we have at the moment.

Senator **Bumpers**. How does that compare with today's dollars for building a coal-fired generating plant?

Dr. **Miller**. Significantly higher. Depending upon its size, coal-fired plants today range between probably $750 and $1,200 and $1,300, which is a fraction of a dollar; let's say $1.30. So it is at least a factor of 10 more expensive.

Senator **Bumpers**. Where do you hope to be by 1985 in the photovoltaics?

Dr. **Miller**. We would like to get the system costs down to around $1.60.

Senator **Bumpers**. Do you seriously hope to ever do that?

Dr. **Miller**. Yes, I sure do. I don't see a reason why we should not.

Senator **Bumpers**. Are you now at $15 to $17?

Dr. **Miller**. And we were at $60 to $70 3 years ago, and at several hundred a few years before that.

Senator **Bumpers**. How much has the cost gone down in the last 3 years?

Dr. **Miller**. It has dropped by a factor of five or more. I believe we are in a sharply decreasing cost curve. Because this is high technology there is a tremendous opportunity for breakthrough. We are talking about the kinds of systems that are amenable to scientific breakthroughs, and I think they are going to come. After we get to the $1.60, that is when you get to a situation where the next factor of two is going to be difficult to come by, but I believe we will get to that and everything that we have done in the past supports that. In 1972 we laid out a cost curve, how we thought the cost of photovoltaics would come down. I don't know if we were lucky or smart or a combination, but it has been remarkably well followed over the past 6 years in terms of the cost reductions.

Senator **Bumpers**. You mentioned in your testimony the shortage or impending shortage of polycrystaline materials. What is that? Is it silicon?

Dr. **Miller**. Silicon. The technology used today is based on what is called single crystal silicon. It is very pure silicon, the kind you have had in semiconductors. With the growth that we see we have a concern that there may be a shortage of semiconductor grade silicon.

Senator **Bumpers**. Do we produce it in the United States?

Dr. **Miller**. Yes.

Senator **Bumpers**. What is the principal source? Is it mined?

Dr. **Miller**. No. The principal source is sand, basically. Silicon is a very common element. There is not a basic materials problem.

Senator **Bumpers**. Do you develop it through a heat process?

Dr. **Miller**. Yes, a very complicated heat process that takes it from normal grade silicon to the highly refined product you need for photovoltaics. That is one part of the program that is taking today's technology and pushing it as far as it can.

Senator **Bumpers**. Does Japan produce all of its own silicon?

Dr. **Miller**. I am not sure. I believe they probably do. There are big chemical manufacturers throughout the world.

The other part of our program is aimed at using new materials, cadmium sulfide, for example, which is a different material, much easier to produce, and which instead of having to go to single crystalline form you can use in an amorphous form. We are looking at processes to up the efficiency of that kind of program. We are trying to push the costs down with today's technology and look at ways of utilizing tomorrow's technology and getting a breakthrough. Everything we have seen says that will happen.

Senator **Bumpers**. If it does not happen we will not get very far with photovoltaics, will we?

Dr. **Miller**. If it does not happen we will not get very far with photovoltaics.

Senator **Bumpers**. Let me ask you now about wind. We dedicated a 2 megawatt windmill in North Carolina last year.

Dr. **Miller**. Right.

Senator **Bumpers**. By whom was that built?

Dr. **Miller**. General Electric with Boeing blades.

Senator **Bumpers**. How big is the windmill?

Dr. **Miller**. It is 200-feet-diameter blades.

Senator **Bumpers**. Is it 2 or 2½ megawatts?

Dr. **Miller**. It depends on the wind speed. It is characterized as a 2 megawatt system.

Senator **Bumpers**. What was the cost?

Dr. **Miller**. It is difficult to give a precise figure because the machine itself was one cost, but it was part of a whole R. & D. effort. The overall R. & D. effort which led to that was about $20 million.

Senator **Bumpers**. What does that convert to, $10 a watt?

Dr. **Miller**. Yes, but the second copy of that machine will be cheaper.

Senator **Bumpers**. How big is the windmill at Sandusky?

Dr. **Miller**. That windmill has been operating for 3 or 4 years. It is a 200 kilowatt machine.

Senator **Bumpers**. How wide is the blade?

Dr. **Miller**. 125 feet.

Senator **Bumpers**. How much wind does it take to operate that windmill at Sandusky?

Dr. **Miller**. They will start at relatively low speeds, a few miles per hour.

Senator **Bumpers**. A speed of 8 miles per hour?

Dr. **Miller**. I don't know precisely the cut in speed, but that is about right. They normally operate at speeds of 18 to 20 miles an hour. That is where the maximum power is extracted.

Senator **Bumpers**. Do these windmills have auxilliary power systems?

Dr. **Miller**. No. They are connected directly into the grid.

Senator **Bumpers**. How many days a year will that plant in North Carolina operate?

Dr. **Miller**. I don't have——

Senator **Bumpers**. Will the wind be sufficient to operate it at peak capacity?

Dr. **Miller**. It was picked because it was an extremely good wind site, and the precise number of days I will have to get for the record. My recollection is much better than half.

[The requested information follows:]

It is estimated that the MOD-1 wind turbine, when operational, will be generating electricity approximately 180 days out of the year.

Senator **Bumpers**. Where is your next one going to be, and how big is it going to be?

Dr. **Miller**. That is the MOD 2 machine, a 300-foot diameter system. It operates at a lower wind speed than the MOD 1, so it produces twice as much energy.

Senator **Bumpers**. When will it be finished, and where will it be?

Dr. **Miller**. October of this year, installed at Goldendale, Wash., connected on the BPA grid.

Senator **Bumpers**. Will this census you are doing on the best wind spots in the United States be finished by the middle of 1981?

Dr. **Miller**. Yes.

Senator **Bumpers**. What are you doing, monitoring all these places?

Dr. **Miller**. We are getting samples on a 15-mile grid countrywide. One of the big difficulties with using the wind as a resource is it is so highly variable. If you go 2 miles away from a good wind site you may have an absolutely calm site. Determining the wind resource is a major undertaking, and we are doing that at 15 centers, going locally, and trying to extrapolate into areas in between.

Senator **Bumpers**. Will a windmill operate as efficiently at 50 miles per hour as 15 miles per hour?

Dr. **Miller**. Up at those speeds the stresses get too large. You want to operate in a range of 10 to 20 miles per hour.

Senator **Bumpers**. Do they feather them automatically?

Dr. **Miller**. Yes. They are remote operated systems. They move into the wind. They sense the wind. They have yaw and pitch control. They turn when the wind reaches a minimum speed. They feather when they reach a maximum speed, and they are synchronized with the grid and provide reliable energy. Clayton, N.Mex., has a system operated for almost 6,000 hours now. At peak usage it provides 15 percent of the total energy of the community.

Senator **Bumpers**. I am glad you are working on smaller technologies because Senator Church was talking about farm stills. It occurs to me that windmills hold a great potential for a lot of farms in this country, especially in the Plains States.

Dr. **Miller**. We have a system developing 1 kilowatt, up to 40 kilowatts, and those are indeed targeted to the farm sector.

Senator **Bumpers**. Mr. Chairman, I have been talking too long already although I do have other questions.

Senator **Church**. Senator Matsunaga.

Senator **Matsunaga**. Thank you, Mr. Chairman.

Thank you for your testimony, Dr. Miller. I am happy to know that you are a little more optimistic about the possibilities of the solar photovoltaic cell than some of your predecessors have been. You note it is a great possibility for developing, and the cost will be down to $1.60 in 1985, did you say?

Dr. **Miller**. Yes.

Senator **Matsunaga**. For your information, I have been informed that prior to 1986 one photovoltaic cell manufacturing company hopes to bring the cost down below $1, possibly to 70 cents. If that is true, then we will be well on our way to using the solar photovoltaic cell as a source of power.

Dr. **Miller**. Absolutely. If we can get to 70 cents a watt for a system cost, not just the array, then we are really in business.

Senator **Matsunaga**. I am glad you feel that way. I remember when Secretary Schlesinger made his final appearance before the Finance Committee we were discussing tax credits for alternative sources of energy. I said, "Mr. Secretary, I was told by the president of a solar photovoltaic cell manufacturing company that in my lifetime I will be driving an electric motor vehicle powered by a solar photovoltaic cell. What is your view?"

Without hesitation, he said, "Senator, I think he was wishing you a long life."

I said, "Mr. Secretary, you are a pessimist. I am an optimist. In the not too distant future when you visit Hawaii on a vacation I am going to take you on a ride in my solar photovoltaic car." And everybody laughed.

Two days after that colloquy appeared on the front page of the Wall Street Journal, I received a call from the Lawrence Livermore Laboratories in California. Dr. Fleming called and said, "Senator, we already have a car powered by solar photovoltaic cells." We invite you to stop by on your way home to Hawaii, one of these days, and we will let you drive it."

I asked, "Do you have a good photographer?" He said, "Yes, we do."

I said, "I will come to have a picture taken and send an autographed copy to ex-Secretary Schlesinger."

That is exactly what I did. I rode in the car and had my picture taken; and I sent it to my good friend, former Secretary Schlesinger. I signed the picture, "To the pessimist from the optimist: Capturing Sparky driving tomorrow's car today."

For a State like Hawaii, Dr. Miller, I see the greatest possibility of the use of solar photovoltaic cells to operate electric motor vehicles in connection with the aluminum air battery which, I am told, will probably be ready for commercialization in 1983. What is your projection, if any, in this area?

Dr. **Miller**. I think that is a very ambitious schedule, Senator. The aluminum air battery, as my colleague assures me, is nothing more than a postcard sized laboratory item at the moment. I think it will be later than 1983 before an aluminum air battery is ready for commercialization.

On the other hand, the aluminum air system does promise, if it can be developed, to be an extremely attractive system.

Senator **Matsunaga**. I was at the Lawrence Livermore Laboratories. I saw the battery and I asked them, "When will this be ready for the market?" And I was told 1986. I asked, "How much are you getting now by way of Federal assistance?" They said, $2.5 million. I said, "Suppose we double that amount of funding. Then how soon then could you get the battery ready for commercialization?" And I was told, 1983; we could shorten the time by half.

I wish you would look into this because, if we have this in combination with solar photovoltaic cells, the power of the cells could be used to reprocess the aluminum oxide. I was told that the most beautiful thing about an aluminum air battery is you can reprocess the waste, aluminum oxide, back into aluminum. In reprocessing you lose only 5 percent of the aluminum. This would be great, especially in Hawaii,where we have sunshine.

Dr. MILLER. Even at night.

Senator MATSUNAGA. With the aluminum battery you have a stored energy and during the day we have direct use of the battery. I am somewhat disturbed that the actual amount budgeted for solar photovoltaic cells is reduced instead of increased.

Dr. MILLER. No; that is misleading. I want to make sure that it is understood that there are two components of the photovoltaic program. One was carried under the solar technology part of the budget, and the other in the solar applications side. That was before the reorganization, and they are now all together. There is $35 million additional in the solar applications side of the program, and so the total for 1981, the request to the Congress, is $175 million for photovoltaics, over $147 million in 1980. So there is a significant increase, although the technology side went down from $147 million to $140 million, and that is what I think you are referring to. But that is misleading.

Senator BUMPERS. Will you promise you will not split those programs again next year and say you have reorganized again?

Dr. MILLER. I hope not. As one of the wags in the Department said the other day, Conservation has just gone through its annual reorganization.

Senator MATSUNAGA. As you know, Dr. Miller, I am most interested in the windmill, and we hear all types of rumors. I contacted you regarding one, the abandonment of a supplementary request for $6 million. Is that true or not?

Dr. MILLER. No, sir, that is not true.

Senator MATSUNAGA. I have been told that you have reduced your request for the $39 million. Did you?

Dr. MILLER. Yes. The request went down $1 million from 1980. That indeed is the case. But, again, it is important to unravel the numbers just a little bit, because otherwise they can be misleading.

In 1980, we were going to be spending $15 million to complete the OTEC–1 project. We will not have that expenditure in 1981 and, therefore, the net result is that our operating budget, which is really the core part of the program, will increase by almost $10 million in 1981.

Senator MATSUNAGA. When do you hope to complete OTEC–1 and to prove the technology?

Dr. MILLER. We are on schedule for deployment in early June.

Senator MATSUNAGA. Is it your plan, then, to proceed with OTEC–1040?

Dr. MILLER. We are planning on issuing a procurement which would have as its result a series of design studies aimed at a 1040 system.

Senator MATSUNAGA. Beginning as of when?

Dr. MILLER. The procurement is going through the last stages of processing right now. I hope we will be able to issue it soon.

Senator MATSUNAGA. You have not in your recent austerity program reduced any of your requests, as were originally planned?

Dr. MILLER. There have been no reductions in the OTEC program to my knowledge, sir.

Senator **Matsunaga**. I am certainly glad to hear that. The OTEC program is one area which, to me at least, since the mini-OTEC was such a success, promises to provide a mass of power, cheaply and cleanly, not only in Hawaii, but in many areas of the country.

As you know, my bill was passed last year. It is pending in the House now. If the bill goes through it will double the funding that you now have. Will you be able to use that additional funding to expedite the program?

Dr. **Miller**. Yes; I think we could, Senator. On the other hand, I do think that at the moment the program is moving along on a prudent course, but clearly, if there is legislation that is signed into law that provides additional funds, yes, I believe we can use those funds.

Senator **Matsunaga**. I am glad to hear that.

Now, as to wind energy, as you know, we have constant wind in Hawaii. I commend you for your part in having selected Ilio Point, on Molokai, as one of the sites of national experimentation and having selected a site on the Big Island. I think we have a very great potential for wind power. We can prove that wind power is indeed an alternative source that can be harnessed easily, readily, and quickly. I am glad to see that you are going into the wind power program.

Dr. Stelson appeared before the energy Conservation and Supply Subcommittee, testifying on energy conservation this past Tuesday. I happened to be at that hearing, coming in on the market testimony and the commercial applications portion of the budget. Do you have anything to do with that?

Dr. **Miller**. Yes, indeed. It reports to me.

Senator **Matsunaga**. He does report to you?

Dr. **Miller**. No, he does not report to me, but the market test and applications program reports to me through the solar program.

Senator **Matsunaga**. Dr. Morse reports to you?

Dr. **Miller**. Yes.

Senator **Matsunaga**. Well, Dr. Stelson did not comment in detail on that portion of the budget, and I would like, if you will, to have you comment on a program which is of special interest to me.

As you know, the low income assistance energy conservation program of the Department of Energy is mostly concentrated on the cold weather States. Now, we have a special energy problem in Hawaii. We have about the highest cost of living in the Nation, as exemplified by the highest gasoline and electricity rates. Hawaii's economically deprived citizens thus suffer more from escalating energy costs than perhaps anywhere else in the country. Yet they are not eligible for any part of that solar utilization economic development program to spend $4 million to expand the solar utilization in low income communities. Now this is one of the very few programs available in energy conservation for the poor people of Hawaii.

Can you elaborate, Dr. Miller, on your program and similar ones which could be applied to Hawaii?

Dr. **Miller**. Yes, I think, Senator, we expect to continue the SUEDE program in 1981. Basically, at least as we see it now, it will be expanded to include over 500 trainees and 1,200 low technology installations at a minimum of 15 sites, both rural and urban. Those sites have not been picked. It is my understanding that it will be a competitive process and that we will pick the sites based on the proposals we receive. But in 1981 we are planning for continuation of the SUEDE program.

Senator MATSUNAGA. And will you look into the possible application of that program to Hawaii's poor, as well?

Dr. MILLER. I will be glad to. I am sure that as we get to the stage where we pick sites Hawaii will not only be notified, but will have advance notice to be assured that you can submit a proposal.

Senator MATSUNAGA. Although people in Hawaii may not freeze to death, they may starve to death because of the escalating cost of electricity and gas. So I would appreciate you expanding that program to include Hawaii.

Dr. MILLER. Do you have information that Hawaii was at any point excluded? I do not. You said, "expanded to Hawaii." It has never been excluded to my knowledge. I presume Hawaii will be included like any other——

Senator MATSUNAGA. Hawaii has no benefit from it. Let us put it that way, probably at the discretion of the Secretary of Energy.

Dr. MILLER. I will look into that, Senator.

[The requested information follows:]

The fiscal year 1981 budget contains $4 million for continued funding of the SUEDE program. Following approval of SUEDE by the Congress, Hawaii will be inlcuded in the grant solicitation process and its grant proposal, when submitted, will be considered for funding.

Senator MATSUNAGA. We were about to be excluded also from the windfall tax measure. We have subsidies for the poor because, as I say, people in Hawaii will never freeze to death on the basis of gas, but we may starve to death in Hawaii if we cannot afford the cost of electricity and gas. It was on that basis that we were allocated a small sum.

Mr. Chairman, I have other questions, but I see I am taking too much time. If you wish to continue your conversation, I can continue to ask questions.

Senator CHURCH. Please proceed with your questions. I understand Dr. Savitz, however, has a plane flight to catch, and nobody has asked her a question in the last hour or so.

Dr. MILLER. I will be delighted to yield to my colleague.

Senator CHURCH. I do not want you to feel offended, Dr. Savitz.

Senator MATSUNAGA. Could I ask Dr. Savitz a question?

Dr. SAVITZ. With regard to the low-income weatherization program, which is where we provide conservation materials for low-income homes and they are then installed by CETA employees, Hawaii at present is not in that program because of the number of heating days that are required to be a participant. That I can go back and look into.

Senator MATSUNAGA. Yes, could you look into the matter to see how we can be qualified under your regulations, what amendments, if any, to your regulations would be required, and if it cannot be done by way of regulation, perhaps by legislation, as an amendment to the budget as it is being considered?

Dr. SAVITZ. I will look into that and get back to you.

Senator MATSUNAGA. I would appreciate that very much.

[The requested information follows:]

DEPARTMENT OF ENERGY,
Washington, D.C.

Hon. SPARK M. MATSUNAGA,
U.S. Senate,
Washington, D.C.

DEAR SENATOR MATSUNAGA: This is in response to your inquiry of March 20, 1980, regarding participation by the State of Hawaii in the Department of Energy's (DOE) Weatherization Assistance Program.

Prior to the program's implementation in 1977, the Department (then the Federal Energy Administration) received correspondence (copies enclosed) from both the Governor of Hawaii and the Manager of the State Energy Office declining State participation, and citing the program's lack of applicability to Hawaii because of its favorable climate conditions. Subsequently, when the regulations were published, Hawaii was not defined as an "eligible State" for participation in the program.

The legislation does not exclude Hawaii. Should the State determine that it now desires to participate, the Governor should make this request in writing to DOE. At that time the regulations can be amended to include Hawaii as an eligible State. I have asked the Regional Office in San Francisco to contact the State for a clarification of their position in this matter.

If we can be of any further assistance, please do not hesitate to contact us.

Sincerely,

MAXINE SAVITZ,
Deputy Assistant Secretary,
Conservation and Solar Energy.

Enclosures.

EXECUTIVE CHAMBERS,
Honolulu, December 8, 1976.

Mr. SAMUEL J. TUTHILL,
Assistant Administrator, Energy Conservation and Environment, Federal Energy Administration, Washington, D.C.

DEAR MR. TUTHILL: Thank you for your letter of November 22, 1976, regarding the Weatherization Program authorized by Congress and the fact that the program as designed excluded funding for Hawaii.

After reviewing the draft I concur with the findings of our respective staffs that Hawaiians have no significant problems that the Weatherization Program could address.

Enclosed is a copy of a letter from Alfred S. Harris of my Energy staff to Stacy Swor of FEA, Region IX, which is in response to a request for comments about the program.

With warm personal regards, I remain,

Yours very truly,

GEORGE R. ARIYOSHI.

Enclosure.

DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT,
Honolulu, Hawaii, December 3, 1976.

Mr. STACY W. SWOR, DIRECTOR,
Conservation Division, Federal Energy Administration, Region IX, San Francisco, Calif.

DEAR STACY: Reference your letter of November 26, 1976, regarding the proposed regulations designed to govern the Weatherization Program authorized by Congress in Public Law 94-385.

Understandably, there is little or no application of this program to Hawaii because of our climatological conditions. Insulating homes would be inappropriate here because of the warm climate and low or negligible number of air conditioned low-income dwellings. In addition, insulating homes would only make a home warmer, especially during the summer months. Hawaiian homes should be de-insulated or opened up for more ventilation if anything.

Do appreciate your asking for our comments, however, and want to thank you and your staff for keeping us so well informed about the program.

Sincerely,

ALFRED S. HARRIS,
Manager, State Energy Office.

Senator CHURCH. Thank you very much.

Have you other questions?

May I just interject a question to whomever can answer it?

I am referring once more to gasohol—I am proceeding on the theory that if we concentrate on one thing we might get something done in that field. I have therefore been concentrating recently on gasohol. I read from the testimony that there is a $2.2 billion appropriation available at present to the Department in this field. The appropriation includes $100 million for feasibility studies, $100 million for cooperative agreements, whatever they may be, $500 million for loan guarantees, and $1.5 billion for purchase agreements. I take it by "purchase agreement" that would be the Government acting as a purchaser of last resort?

Dr. SAVITZ. That also includes price supports.

Senator CHURCH. Well, now, how long has this money been available?

Dr. SAVITZ. Since November.

Senator CHURCH. Since last November?

Dr. MILLER. Yes.

Senator CHURCH. Has any of it been used?

Dr. SAVITZ. The solicitations for the cooperative agreements and feasibility studies were issued in February of this year, and they close in April. We plan to award the $200 million by June in contracts. And the solicitation for the——

Senator CHURCH. That $200 million will be made available in June in what form or for what purpose?

Dr. SAVITZ. $100 million for feasibility studies and $100 million for cooperative agreements.

Senator CHURCH. By "cooperative agreements," would you explain to me exactly what you mean?

Dr. SAVITZ. Those often can be between States or private entities as a contractual mechanism. Instead of a contract or a grant we sign a cooperative agreement as a means of——

Senator CHURCH. Meaning, you put up part of the money and they put up part of the money?

Dr. SAVITZ. Yes, cost-sharing is encouraged in both of those. The same way we give a grant, a cooperative agreement is a type of agreement between the Government and whoever is going to get our money.

Dr. MILLER. If I could add to that, the cooperative agreement, as a procurement vehicle, is an extremely flexible method of entering into a business arrangement with the private sector. It provides them with much less in the way of restrictions on what they can do in the way of patents and things of that sort than the formal contracting process, so it is an extremely attractive vehicle for business. They like it much better than they do the normal contracts that the Federal Government lets.

Senator CHURCH. What about loan guarantees? Have you issued any loan guarantees so far?

Dr. SAVITZ. There will be a conference next week on the draft solicitation for loan guarantees. That formal solicitation should be out in April, and then we will make loan guarantee awards this summer.

Senator CHURCH. Where do you stand on the $1.5 billion for purchase agreements?

Dr. SAVITZ. I think it is the same as the loan guarantees. The two are coming at the same time in the same way that the feasibility studies and cooperative agreements are being done in parallel. The intent is to get that money all awarded before the end of the year.

Senator CHURCH. It seems to me to follow rather logically that, if there are alcohol plants presently operating and if gasohol is presently on the market, and it is being purchased and being sold at prices that are sufficiently attractive that it is finding its own market, then the main thing we need to do is to make capital available to people who want to build alcohol plants, people who are prepared to build them, who have done engineering studies and are ready to go. I hope we do not get boxed in so much paper work and bureaucractic red tape that this becomes another obstacle rather than a way to expedite and accelerate the production of alcohol.

There are many people out there ready to get on with the business of making gasohol. They are not just kooks. They are businessmen of substantial experience. They are people that are connected with cattle feedlots. They are municipalities that are working on this. I just came from Twin Falls in my own State, where the Chamber of Commerce and the leading businessmen of the community have an industrial park. They have a scheme that will pull these various plants together so one can supplement another in ways that will greatly reduce energy consumption and at the same time produce both ethanol and methanol. All the gasohol used within the industrial park would save fuel and make the whole industrial complex largely energy self-sufficient.

There are all kinds of wonderful ideas out there, backed up by competent engineers. It just seems to me that the Government instead of trying to do it all—pilot projects, demonstrations, and this kind of thing—ought to get off the dime and get the money moving and the plants underway. If the Department would just do that.

Dr. MILLER. We agree with that, Senator.

Senator CHURCH. Let us do it, then. Let us make the pledge that we are going to do it this year because you have the money available. You are going to get more money for this purpose in the energy package because one third of the energy package deals with alcohol fuels. The Congress is going to be very supportive, but one thing we are pleading with you to do is to move that money out. Let us get the plants started; let us get it going; let us have something to show.

There is an attitude in the country that we are spending $10 or $11 billion a year in the Department of Energy and we have not a blessed thing to show for it. That may be a little unfair, but, by and large, I would have to say that there is plenty of reason for people to believe that. They cannot see any signs of progress anywhere, and the Department of Energy has been around for some time now, and a lot of money has been pumped into it. Here you do not have to wait 5 years for the development of the technology, and another 5 years for a pilot plant, and another 5 years for a demonstration plant. We do not have to go through that.

There is one place in my State I have been trying for 8 years now to get a little pilot plant built to demonstrate that natural hot water can generate electricity. We have not built it yet. Every year there is a little dribble of money given to this pilot plant to keep it alive. Maybe by the end of the decade we will have it built. Meanwhile, it will have cost three times as much as it should have cost because of the dribble, dribble, dribble method.

I would urge you, please—here is a place and a program on which to focus on getting the money out, getting the plants under construction, getting a program going that is urgently needed by the country. We now have all the technology we need and, if there are ways to perfect that technology, we can learn from building, learn from the experience, and perfect it as we go along.

We will have some additional questions to submit that the staff will prepare and submit in writing. We hope you will get your answers back to the committee as promptly as possible.*

I do not want you to miss your plane, Dr. Savitz.

Everyone else has abandoned me, so I will adjourn the hearing.

[Whereupon, at 4:16 p.m. the hearing was recessed, to reconvene Monday, March 24, 1980.]

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*See appendix I.

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DEPARTMENT OF ENERGY FISCAL YEARS 1981-82 AUTHORIZATION

(Civilian Applications)

MONDAY, MARCH 24, 1980

U.S. Senate,
Subcommittee on Energy Research and Development,
of the Committee on Energy and Natural Resources,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:30 p.m., in room 3110, Dirksen Office Building, Hon. John Melcher, presiding.

Present: Senators Melcher, Matsunaga, and Domenici.

Also present: Willis Smith, professional staff member.

OPENING STATEMENT OF HON. JOHN MELCHER, A U.S. SENATOR FROM THE STATE OF MONTANA

Senator Melcher. Today the Subcommittee on Energy Research and Development continues its hearings on the fiscal year 1981 Department of Energy authorization request.

Our hearing today ranges over a broad set of topics, including magnetic and inertial confinement fusion, basic energy research, uranium enrichment, geothermal energy, electric energy systems, and nuclear material security and safeguards.

I have a few more comments and I insert my statement in the record.

[The prepared statement of Senator Melcher follows:]

Statement of Hon. John Melcher, a U.S. Senator From the State of Montana

Today the Subcommittee on Energy Research and Development continues its hearings on the Fiscal Year 1981 DOE authorization request. Our hearing today ranges over a broad set of topics, including magnetic and inertial confinement fusion, basic energy research, uranium enrichment, geothermal energy, electric energy systems, and nuclear material security and safeguards.

The programs under the Director of the Office of Energy Research, which are comprised of the magnetic confinement fusion, basic energy sciences, and some general science programs, have budgets for FY 1981 which at least keep pace with inflation. The magnetic confinement fusion program is now receiving considerable attention due to the belief on the part of some members of Congress that the consistent progress in the program in the last ten years warrants an acceleration in the program schedule through increased funding. We will explore the progress in the program when Dr. Pewitt, the Deputy Director of the Office of Energy Research, testifies this afternoon.

The areas of geothermal energy and uranium enrichment have fared less well in the budget proposed for fiscal year 1981 without taking into account potential cuts during the budget revisions currently taking place in the Administration. The testimony of Dr. Ruth Davis, the Assistant Secretary for Resource Applications, will hopefully provide us with a clear assessment of what the prospects for geothermal energy utilization will be during the next decade, given the seemingly slow progress toward expanded use of geothermal resources in the past decade. I am sure that members of the Committee will have questions regarding the pace and timing for the construction of the gas centrifuge enrichment plant at Portsmouth, Ohio, as well as cutbacks in the national uranium resources evaluation program.

For the purposes of comparison, the Subcommittee will have an opportunity to receive testimony from Dr. Duane Sewell, the Assistant Secretary for Defense Programs, on the progress being made in inertial confinement fusion. The stretch-out in the funding for the NOVA project at Lawrence Livermore Laboratory raises a question about the directions and goals of the inertial confinement fusion program. The Subcommittee will also be interested in learning the progress being made in the nuclear materials safeguards area regarding sensitive nuclear fuel cycle facilities.

Senator **MELCHER**. Our first witness today is Dr. Nelson Pewitt, the Deputy Director, Office of Energy Research, Department of Energy. Dr. Pewitt.

STATEMENT OF DR. NELSON D. PEWITT, DEPUTY DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY, ACCOMPANIED BY JAMES LEISS, JAMES KANE, KATHLEEN JOHNSON, DR. JOHN CLARKE, AND ANTOINETTE GRAYSON JOSEPH

Dr. **PEWITT**. Thank you, Mr. Chairman. With your permission, I have a prepared statement I would like to submit for the record, and then I would like to summarize that statement for you briefly.

Senator **MELCHER**. Without objection, the entire statement will be made a part of the record and, Doctor, please proceed.

Dr. **PEWITT**. I think before you you have a copy of my statement. I will speak to the charts in the back of the statement in the sequence that they are presented there. On behalf of Ed Frieman, the Director, I apologize for his absence today. He wanted to be here but he is unfortunately out of town on travel.

I will summarize the statement, and I have colleagues here who will be able to respond to any specific questions that may come up.

My intention is to provide a brief overview of the budget and briefly describe some of the organizational changes that the Office of Energy Research has instituted since it last testified to this committee, and then present the highlights of the fiscal year 1981 budget.

On the first chart you have in front of you the budget request for the office as summarized. The programs that the Office of Energy Research conduct include the national programs of high energy and nuclear physics, the energy supply R. & D. programs of basic energy science, magnetic fusion, technical assessment projects, and university research support.

Two other programs are included in this budget. The first is technical program and policy analysis, which consists solely of salaries and expenses for the staff which support the Director in his responsibilities as technical adviser to the Secretary of Energy.

The last line in the chart is a new program I will speak to briefly in just a second; multiprogram general purpose facilities. Overall our request above 1980 shows an increase of $198 million.

However, there is a new line, multiprogram and general purpose facilities that we included in the energy research budget, that represents an overall department commitment to upgrading the capital plant at our national laboratories. If that is deducted, the overall increase is about 13 percent, Depending on how one calculates the escalating cost of conducting business, that is either an overall slight increase or approximately a level budget.

On chart II we list some of the categories of projects contained in our general purpose facilities budget request. This is a program to upgrade the national laboratories' general purpose facilities. These are facilities that are used by more than one program and have in the past not received sufficient department-wide attention.

This program represents the commitment by the Department to correct deficiencies at the national laboratory system. That we estimate to be on the order of $800 million.

The second chart represents a schematic diagram of some of the organizational changes we have made since we last testified. The significant changes include the abolition of the Office of Research Policy and combining those functions either as offices reporting directly to the Director, or combining them with our Office of Program Analysis. That change was made to establish clear lines of responsibility and accountability for the function that we have to perform in our advisory capacity to the Secretary.

Also, significant changes were the addition of the Office of Magnetic Fusion Energy to the Office of Energy Research. This came about because of an overall organizational change within the Department.

Another function added to the Office of Energy Research was the university lab cooperative program. This is a program that provides for interactions between university and laboratory personnel primarily through summer visits of university personnel at the laboratories to make use of laboratory facilities and to work with laboratory personnel.

Two additional changes were made. The Office of Nuclear Policy was transferred to the Assistant Secretary for Policy and Evaluation, and with the completion of the international fuel cycle evaluation, the Office of the International Fuel Cycle Evaluation Coordinator has been abolished with its functions spread between the Assistant Secretary for Nuclear Energy and the Office of Energy Research.

Chart IV shows the current organizational structure of the office.

On chart V we show some of the highlights of the 1981 budget. The 1981 budget includes a commitment to maintain the long-range plan of the high energy physics program which includes sustaining an active program of research, a credible program of construction for the future viability of the program, and the operation of three national laboratories.

The nuclear physics program is maintained at the 1980 level. We are in the process of developing a long-range plan for that program also. We will be ready to present that to the staff of the committee or the committee itself later this fall.

There is a significant increase in the basic energy sciences program to address the necessity for the Department to establish a sound technical base for the applied and development programs of the Department.

Also included is an intention on our part to increase the role of the university in energy research and there is a significant increase in the total funding for universities that we plan this year. We intend in the basic energy sciences program for a larger fraction of the overall program's operating budget to support research at universities.

On chart VI, I highlight a few of the areas of emphasis in the Office of Energy Research this year, specifically in the area of basic energy sciences, addressing the problems of fossil energy production, nuclear waste isolation, exploring advanced concepts for solar, and a number of other areas that we think have significant potential for contributing to our energy solutions.

New starts included in the 1981 budget are shown on chart VII. I would like to speak to two of them. In the case of the multiprogram general purpose facilities, such facilities have been funded in the past by program landlords. In an attempt to raise the level of review in the Department to an appropriate assistant secretary level, as opposed to program level review, we are showing this program as a separate line item.

We intend to start, if authorized, phase I of the Tevatron project. There has been a bit of confusion in the past about that particular project. We have included in our request funds for completion of the energy saver project which includes the installation of the magnet at the Fermilab.

The Tevatron project would provide an ability to collide beams in that ring of magnets. Our request for $2 million in 1981 would allow us to coordinate the construction of interaction regions at Fermilab with a period when magnets are to be installed in the Fermi magnet ring. This will save considerable downtime of the accelerator in the outyears if we start the Tevatron in 1981.

On chart VIII we show a photograph of the Isabelle project at Brookhaven National Laboratory. We are continuing that project. It is the largest project that we currently have in the high energy physics program, with a completion date now planned for 1986.

On chart IX we show the basic energy science program request by subprogram elements. The nuclear science request is essentially level with 1980, with only a small adjustment for the impact of inflation.

The material sciences request, although appearing to be down in constant dollars, reflects a change from a construction project budget to one that will bring two new facilities into operation in 1981. These are the intense pulse neutron source project, at Argonne National Laboratory; and the sychrotron light source at Brookhaven National Laboratory.

In the chemical sciences program, the increase is $9.4 million. This will allow us to expand our efforts in some of the nonnuclear chemistry areas, and to provide for initial operation of the combustion research facility at Livermore.

The engineering mat and geosciences program request includes a significant increase. That request is consistent with our understanding of the importance of these disciplines.

The geosciences program is receiving special emphasis because of the low level of research we have conducted in the past and our view that geosciences, being the study of the source of most of the energy supplies and the ultimate burial ground for most of the refuse from energy production, needs additional attention.

The mathematics program is receiving significant attention because of the impact of computer modeling and the need for enhanced capability in computer modeling in all energy systems.

The engineering program is a relatively new program in the Department of Energy, only 2 years old. It reflects the problems of engineering integration that we are facing with a number of our demonstration plants.

Advanced energy projects is increased. This is the program where we support studies of projects that are not easily fitted into our discipline-oriented research programs, and we investigate proof of principle ideas.

The biological energy research program is also relatively new to Energy Research. It represents one of the most substantial opportunities in the energy research area because although much research has been done on biological systems for a number of years, that research has primarily been conducted with the goal of increasing food and fiber production and not with the goal of increasing biomass for energy production.

We think this is an area of great potential.

On the next chart, we show the breakdown of the magnetic fusion energy program. We are asking for a substantial increase above the fiscal year 1980 level. This increase reflects the Department's commitment to this program, to achieving its highest potential, and it also reflects the significant advances that the program has made in the last 2 years.

Although it is a significant increase over 1980 in terms of constant dollars, it is not an increase over prior years.

The Department is currently reassessing the direction of the magnetic fusion program based on the successes that the program has had in the last 2 years when we last did a comprehensive review of this program. We expect that assessment to be done by June, and we will have a definitive policy after that date on the future of this program.

We have no reason to believe that the new policy will be inconsistent with our current policy toward the program. It is more of a question of what is the appropriate next step rather than the long-range nature of the program.

On chart XI, we show the technical assessment projects program. The first line is assessment projects, which consists of funds to fulfill our role of advising the Secretary on the technical gaps, duplications, et cetera, of all of the technical programs of the Department. It is a very small amount of money from which we get a great deal of leverage.

The next line is the satellite power systems program—SPS. This is the fourth year of funding for the SPS assessment program. We currently plan to complete the 3-year assessment this summer. The 1981 request would provide a bridge to either a ground-based exploratory development program in the outyears, or some other orderly transition for that program.

Advanced technology projects is one of the programs that Dr. Frieman and myself are most enthusiastic about. I will give you some specific examples of the items we are working on there as opposed to in the advanced energy projects program.

This program consists more of exploring engineering feasibility and transitioning ideas into development programs.

On chart XII I show some of the advanced technology projects that we have currently underway or have in some stage of initiation. I won't touch on all of these. We don't have time. I am running a little bit over already.

I would just like to point out one of our recent successes, a project that was transitioned into advanced technology projects from the advanced energy projects, the solar photochemical splitting of water. One of the very high value energy materials is, of course, hydrogen, and this is an attempt to use photochemistry in a catalytic process in order to release hydrogen.

I will touch finally on the university research support program which consists of our efforts to provide institutional support to universities via a number of mechanisms.

Included in our request for 1981 at this time in university institutional agreements is an increase of $3 million which would provide for problem-oriented research at a number of universities around the country in order to attempt to fill a gap that we have detected between the basic research programs and the applied development programs.

University reactor fuel assistance consists of support for refueling of selected university reactors around the country, and it also provides this year for some sharing of university reactor facilities by universities in the vicinity that do not have their own reactors.

In the university laboratory cooperative program, we are asking this year for a $1 million increase, the first increase this program has had in many years, at least four. It will provide for greater interaction between the university community and the national laboratories.

With that brief summary, my colleagues and I are prepared to answer any of your questions.

[The prepared statement of Dr. Pewitt follows:]

STATEMENT OF NELSON D. PEWITT
DEPUTY DIRECTOR
OFFICE OF ENERGY RESEARCH

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
MARCH 24, 1980

Mr. Chairman and Members of the Committee:

I am pleased to appear before you today to discuss the FY 1981 budget request for the programs which are the responsibility of the Director of Energy Research, including both outlay and non-outlay activities. The outlay programs for which this office is responsible are: 1) High Energy Physics, 2) Nuclear Physics, 3) Basic Energy Sciences, 4) Magnetic Fusion Energy, 5) Technical Assessment Projects, and 6) University Research Support.

The FY 1981 budget authority requested for the Energy Research programs is summarized in Chart I. The total budget authority requested is $1,235.5 million, an increase of $198.3 million over FY 1980. The request for High Energy Physics is $358.8 million, an increase of $33.7 million over FY 1980. For Nuclear Physics, $115.5 million is requested, an increase of $10.9 million. The Basic Energy Sciences request is $259.8 million, an increase of $30.6 million over FY 1980. For Magnetic Fusion Energy, $403.6 million is requested, an increase of $48.0 million. The request for Technical Assessment Projects is $21.2 million, an increase of $7.7 million. Finally, for University Research Support, $14.3 million is requested, an increase of $7.2 million.

The next two lines on the chart differ from the other budget activities and require some explanation. The first, Technical Program and Policy Analysis, represents the request for the personnel resources required to carry out a number of Department-wide responsibilities assigned to Energy Research in the

Department of Energy Organization Act (P.L. 95-91) or by the Secretary of Energy, which are beyond the scope of the six outlay program areas. This request of $2.0 million is for the salaries and related expenses for the personnel in the Offices of Program Analysis, Field Operations Management, Advisory and Liaison, and Nuclear Non-Proliferation. It does not include any funds to support contractors. The activities of these personnel will be described in more detail shortly.

The last line, Multiprogram General Purpose Facilities, is a new program aimed at alleviating deficiencies in facilities at our multiprogram laboratories. The goal of this program is to rehabilitate, replace or expand existing multiprogram facilities at the laboratories in order to make them safer, more environmentally acceptable, reliable, and cost effective in supporting DOE research. Multiprogram facilities (e.g., support buildings, site utilities and roads) are those in which no one program uses more than 60% of the facility or its services. The laboratories are Argonne, Brookhaven, Lawrence Berkeley, Ames, Oak Ridge, Pacific Northwest, Idaho National Engineering, and Hanford Engineering Development Laboratories. Also included are non-weapons related multiprogram projects at Lawrence Livermore, Los Alamos, Sandia, and Savannah River Laboratories.

This budget request is included under the Energy Supply Research and Development appropriation because these multiprogram laboratories serve primarily the energy technology programs under that appropriation. The Office of Energy Research is taking the lead in preparing and presenting this request because of our responsibility to advise the Secretary on the well-being and management of the nondefense multiprogram laboratories.

According to a 1978 study of DOE's multiprogram laboratory facilities, conducted by an A&E consultant to DOE and using uniform evaluation criteria, there exists an estimated $800 million backlog of projects to correct deficiencies. The FY 1981 budget request includes 17 separate projects which represent the first step in alleviating these deficiencies. Chart II shows the distribution of these funds to the key areas of buildings, utilities, and environment, safety and health. The selection of these projects is made jointly by the Multiprogram GPF Review Committee, consisting of the Director of Energy Research and the Assistant Secretaries for Nuclear Energy, Environment, and Defense. The Office of Energy Research chairs the Review Committee.

ADVISORY AND ANALYTICAL ACTIVITIES

Before I discuss the Energy Research outlay programs in detail, I would like to take a few moments to describe some of our other roles within the Department of Energy, particularly with regard to our advisory role, which is an important factor in the accomplishment of our overall mission. I will also describe the organizational changes that have taken place in the last year.

The Office of Energy Research carries out a broad range of advisory, coordination and program management activities related to the Department's energy R&D missions. In addition to management of the Basic Energy Sciences, High Energy and Nuclear Physics, and Magnetic Fusion Energy outlay programs, the Director of Energy Research provides independent technical advice to the Secretary on matters relating to the Department's energy R&D programs and its non-weapons multipurpose laboratories. The Director also plays a major role in the Department's nonproliferation activities and is responsible for advising the Secretary with respect to the education and training activities needed to provide a cadre of scientific personnel to energy R&D programs.

The analytical activities necessary to develop advice aimed at identifying gaps and duplications in the Department's programs are carried out by our Office of Program Analysis. That Office also supports the Department's international strategic R&D planning and provides analytical staff support to the Under Secretary on a variety of projects. For example, the Office is providing to the Under Secretary an independent technical assessment of DOE's FY 1982 budget submission. The Technical Assessments activity, also included under the Office of Program Analysis, will be discussed later with the outlay programs.

The Office of Nuclear Non-Proliferation participates in the development of international U.S. nuclear policy and on all major issues related to nuclear non-proliferation. The Office of Energy Research has historically played a major role in DOE's activities in this field. Representative activities have included coordination of DOE and U.S. Government activities in the International Nuclear Fuel Cycle Evaluation (INFCE), participation in DOE's Non-Proliferation Alternative Systems Assessment Program (NASAP), and active input to U.S. non-proliferation policy and its implementation in general. The Office of Nuclear Non-Proliferation is now actively involved, for example, in interagency planning of U.S. Post-INFCE activities, international studies of important nuclear matters such as spent fuel management and plutonium storage, as well as a host of other activties aimed at assuring that the United States and the world have the opportunity to reap the benefits of peaceful nuclear energy while minimizing the risks of the spread of nuclear explosive capabilities.

A third major activity is carried out by the Office of Field Operations Management, which supports the Director's mandate to advise the Secretary on the well-being and management of the Department's multiprogram nonweapons laboratories. This Office has developed several management tools which the Department is now using to administer its network of R&D facilities across the country. These include the institutional planning process, lead mission assignments, and laboratory appraisals.

The five year Institutional Plan, updated annually, provides guidance for long-range planning and budget preparation and is the baseline for placement of appropriate work at the laboratories. The purpose of lead mission assignments is to establish responsibility and authority in the field for day-to-day project management and program execution. The laboratory appraisals integrate program performance evaluations with management reviews to give a comprehensive assessment of each institution's strengths and areas of improvement. Finally, the Office of Field Operations Management has played a major role in highlighting for the Department the need to raise the visibility of and to assign appropriate funding priorities to the general purpose facilities at the multiprogram laboratories, which I mentioned earlier.

Before moving on to the outlay programs, let me comment briefly on the organizational changes which have occurred since last year. Chart III summarizes these changes, and

Chart IV shows the new organization as approved to date. The Office of Research Policy, which formerly housed the Technical Assessments, Advanced Technology Projects and Satellite Power System activities, as well as the R&D Coordination Council and the Energy Research Advisory Board, has been abolished. The Office of Program Analysis is now responsible for Technical Assessments, and the Satellite Power System project office is under the Office of Basic Energy Sciences. We have established an Office of Advisory and Liaison Programs to house the Energy Research Advisory Board; and the Advanced Technology Projects staff now reports directly to the Director. The major change in outlay programs, of course, is the addition of the Magnetic Fusion Energy program to our organization. DOE's University/Laboratory Cooperative program, formerly under Intergovernmental and Institutional Relations, is now a part of our University Research Support activity. In addition, the Office of Nuclear Policy has been transferred to the Assistant Secretary for Policy and Evaluation.

We are convinced that these changes were necessary to improve the management and effectiveness of the Office of Energy Research. In FY 1980, the net result of transfers of functions and manpower into and out of Energy Research is an increase of 2 in full time personnel.

OUTLAY PROGRAMS-
INTRODUCTORY COMMENTS

At this time, Mr. Chairman, I would like to present some highlights of our FY 1981 budget request, as summarized in Chart V. I will discuss these as I go through each of the programs in the following sections. The next, Chart VI, lists the areas we are emphasizing in the FY 1981 request. Included among others are research basic to nuclear waste isolation; basic research related to advanced solar concepts; increased emphasis on university research; and cooperative efforts with the People's Republic of China and Japan. Chart VII summarizes the new starts included in the budget request, which I will be discussing in more detail later.

HIGH ENERGY PHYSICS AND NUCLEAR PHYSICS

The first two programs I will discuss today are High Energy Physics and Nuclear Physics. While these two programs do not directly support the Department's energy technology programs, they do play a crucial role in man's basic understanding of matter and energy and also provide fundamental knowledge for meeting the longer range needs of society. For these reasons, the Department supports these programs as a National Trust.

HIGH ENERGY PHYSICS

The FY 1981 budget request of $358.8 million for the High Energy Physics program is in accord with a long-range plan which will maintain U.S. world leadership by providing a budget floor for planning purposes. The FY 1981 request marks the third year of the plan. The plan is enabling us to reach our program goals and objectives based on an orderly phase-in of needed new facilities while allowing for an on-going national high energy physics program that is both productive and in the forefront of research. The plan provides for the new facilities with advanced capabilities which are required to sustain research progress. It also provides for operation of a three major laboratory system: Brookhaven National

Laboratory in New York, Fermi National Accelerator Laboratory in Illinois, and the Stanford Linear Accelerator Center in California. Finally, it provides for a near constant rate of accelerator utilization, which will allow productive research at these facilities.

The FY 1981 budget includes budget authority of $45 million to continue construction of the Intersecting Storage Accelerator (ISABELLE) project at Brookhaven National Laboratory (Chart VIII). This project will give the United States world leadership in proton-proton colliding beam capabilities. It was initiated in FY 1978 and is scheduled to begin operation in FY 1986. Also included is budget authority of $19.6 million to complete construction of the Energy Saver project at the Fermi National Accelerator Laboratory. It replaces the present copper magnets with superconducting magnets that use substantially less electric power. This will save a significant amount of electricity over the existing system. Construction was initiated in FY 1979 and is planned for completion in FY 1982.

Our request includes a new start for the Tevatron, Phase I project at the Fermi National Accelerator Lab. We are requesting initial budget authority of $2 million for this project. It will modify the Energy Saver superconducting accelerator ring so that it can be used as a 1-Tev proton on 1-Tev antiproton colliding beam storage ring. The project will be completed in FY 1983.

Mr. Chairman, we are extremely pleased with the effectiveness and contributions in the high energy physics program, which have been greatly aided by adhering to a stable plan. It is enabling us to phase in needed facilities systematically, and to maintain

leadership at the frontier of high energy physics research--all within an approximately level budget in terms of constant dollars. Recent experimental results in this program are providing strong evidence to support the unification of two of the four fundamental forces of nature, the electromagnetic and weak forces. The theoretical work behind these discoveries was recognized by the awarding of the 1979 Nobel Prize in Physics to three physicists, including two U.S. theoretical High Energy physicists. Through these discoveries, we are moving toward a comprehensive picture of the fundamental nature of matter and energy.

Our FY 1981 request will allow us to maintain the utilization level of the AGS at Brookhaven, the Fermilab 400 GeV program, and non-PEP facilities at SLAC at near the 50% level. It will also allow the U.S. to maintain its competitive worldwide position in high energy physics. At the same time, we are continuing our efforts in scientific and technological cooperation with nations such as the People's Republic of China and Japan.

NUCLEAR PHYSICS

The FY 1981 budget request for the Nuclear Physics program of $115.5 million provides an increase of $10.9 million over the FY 1980 level. The increase will help us to meet the primary objectives of this program, which include long range basic research into the structure and interactions of nuclei, the operation of national user facilities, the maintenance of a frontier research capability, and the identification and transfer of practical applications derived from this research.

We are currently working to develop a plan which will provide an adequate level of funding necessary for the construction and capital equipment portions of the Nuclear Physics program, while accommodating the need to upgrade existing facilities. Such a plan will allow for a balanced, national nuclear physics program capable of producing fruitful research and maintaining our position as a world leader in this field. One of the recent accomplishments in this program involves pi meson scattering experiments at the Los Alamos Meson Physics Facility and electron scattering experiments at the Bates Accelerator. Identification and examination of the configurations to which nuclei can be excited when struck by an energetic electron, pi meson, or other probe, permit rigorous test of theories of nuclear structure, and are leading to improved understanding of the mechanisms by which these probes interact with nuclear matter.

Our FY 1981 request includes $8.9 million in budget authority for continuation of the National Superconducting Cyclotron Laboratory project at Michigan State University, which is scheduled for completion in FY 1984. It also contains a new start for the Argonne Tandem-LINAC accelerator system (ATLAS). We are requesting initial budget authority of $4 million for this advanced heavy-ion accelerator system. This facility will extend to a great degree both the energy and mass range of ion beams available for precision studies in nuclear physics.

BASIC ENERGY SCIENCES

The next program I am going to discuss is Basic Energy Sciences which, together with the Technical Assessment Projects and University Research Support programs, provides support for expanding the knowledge base which scientists, engineers, and mathematicians need in order to develop improved energy technologies, now and in the future. Chart IX provides a summary of our request of $259.8 million for this program.

Basic Energy Sciences is the major program in the Department of Energy which plans, supports, and administers basic research in the physical and energy-related biological sciences, engineering, and mathematics.

The primary objective of the program is to support the best scientific minds and provide them with the necessary research facilities to assure that all energy technologies will have a strong scientific foundation from which to work in the future. As one would expect, the effort in Basic Energy Sciences is very broad in scope, supporting research in physics, chemistry, biological energy conversion, the materials sciences, engineering, geosciences and mathematics.

We believe that the overall basic research program within the Department of Energy should be of a size and scope to assure the health of those disciplines which are of importance to the long-term development of energy technologies. At the same time, it must be recognized that an increased budget for this program is essential if DOE is to meet its responsibilities to insure basic research efforts fully adequate in scope and balance to support the technology programs of the Department. Several of the high priority areas which require expansion include: scientific studies basic to nuclear waste isolation, advanced solar concepts, engineering research, applied mathematics and computer sciences, the geosciences, and high risk/high-payoff advanced energy projects. An example of how basic research discoveries can enhance energy alternatives is the recent development of a new technique, using ion implantation and laser annealing of semiconductors to prepare extremely efficient solar photovoltaic cells. The technique has the potential for mass production of solar cells at lower costs.

I would like to emphasize that vigorous efforts are being made to assure that the Department's program of basic research is pertinent to future energy development efforts. To that end, we are continuing to work in direct and close cooperation with the applied energy technology programs, both formally through committees, workshops and working groups and informally through such methods as co-location of research. An example of one of the formal committees is the DOE Energy Materials Coordinating Committee, made up of representatives from 24 divisions within the Department that are involved in materials research, including Basic Energy Sciences.

Another example of coordination is the Research Assistance Task Forces, which consist of personnel from the Basic Energy Sciences Materials Sciences program and from applied technology programs, who come together to look at specific problems. Examples have been Task Forces with Nuclear Energy, looking at canisters for nuclear waste; with Conservation, to examine high temperature batteries and the metal air battery; and with Transportation, on the Sterling engine.

Included in our FY 1981 request is $99.9 million for Materials Sciences. This request allows for increased emphasis in areas such as solar energy, nuclear waste isolation and fossil energy. Much of the increase in operating expenses ($13.0 million) will be used to meet commitments associated with the new facilities under development or recently completed. These include the Intense Pulsed Neutron Source-I at ANL, the National Synchrotron Light Source at BNL, and electron microscopy facilities at LBL, ORNL, and ANL. The Chemical Sciences request also reflects an increase, which is required to begin effective use of the new Combustion Research Facility at Sandia-Livermore, and to strengthen the research effort in the highest priority energy-related areas.

Finally, the increase of $9.4 million for Engineering, Mathematics, and Geosciences reflects the importance of the results already being realized, the overwhelming flow of truly excellent ideas for additional research, and the resulting high priority assigned by DOE to getting more researchers actively engaged in these areas of energy research. For example, in Engineering Research, emphasis and high priority are accorded to research topics filling gaps in fundamental data and understanding essential for long-range advances in energy processes and systems. These research efforts will enhance our ability to raise energy system efficiencies, to open new technology opportunities, to improve reliability, and to extend the life of energy systems.

MAGNETIC FUSION ENERGY

The FY 1981 budget request for Magnetic Fusion Energy is $403.6 million (Chart X). The Department's goal with regard to magnetic fusion energy is to develop its highest potential in an environmentally and economically acceptable way. It is an ambitious goal--but a worthy one given our increasingly limited energy resources. A major review of the fusion program conducted in 1978 concluded that the program was progressing well. Expectations were high for continued technical progress in the succeeding years. These expectations continue to be fulfilled. During the last two years, the fusion community both in the U.S. and worldwide has gained confidence in the prospects of creating useable energy from fusion reactors. This confidence stems in part from recent progress in obtaining better values for key parameters that approach those required for the fusion process, and, in part, from enhanced understanding of basic plasma processes.

A growing scientific and technological base is essential if we are to expand on recent achievements in a number of areas. In

1978, tokamak experimental results demonstrated that both the plasma confinement and temperature required for a tokamak reactor could be achieved. During 1979, a record level of plasma pressure in a tokamak was achieved and two new heating techniques were demonstrated. The ability to fuel a reactor grade plasma was also demonstrated.

Non-tokamak concepts, too were advanced. The Tandem Mirror Experiment (TMX) at Lawrence Livermore Laboratory demonstrated that the basic concepts of the tandem mirror approach are valid. Progress in this and other magnetic confinement concepts reinforces our expectation that it should be possible to develop an optimized reactor configuration from the several types of magnetic confinement concepts under development.

The technological base for fusion energy also continues to grow with fabrication and installation of equipment at the Large Coil Test Facility at Oak Ridge and the Tritium Systems Test Facility at Los Alamos, the collection of data on initial radiation effects at the High Intensity Neutron Source Facility at Lawrence Livermore Laboratory and the testing of the neutral beam injectors for the Tokamak Fusion Test Reactor (TFTR) facility. In addition, construction of the Fusion Materials Irradiation Test Facility at Hanford is underway.

We are now looking beyond the demonstration of scientific feasibility to examination of practical aspects of a fusion reactor. The understanding gained from our scientific and technological programs indicates that a single integrated systems facility may be needed to allow engineering tests and technology development in a power reactor environment. This is the Engineering Test Facility. Present program thinking indicates that it will play the central role in developing, testing and demonstrating the technological feasibility of magnetic fusion energy and it should provide the framework for the required engineering data base.

The rapid technical developments in fusion research during the two years since the 1978 review suggest that a new evaluation of the program is now appropriate. Of the array of complex issues now facing the program, perhaps the dominant one is the choice of the next major steps to be taken in proceeding from the current generation of experimental devices toward generation of economic fusion power production. A concomitant concern is the overall DOE development strategy for fusion energy, including the pace, scope and funding of the program. For these reasons, we have initiated a comprehensive review of the program. The review will be headed by Dr. Solomon Buchsbaum, Chairman of the Energy Research Advisory Board, and will focus on the progress, status, plans and prospects for magnetic confinement fusion. We plan to optimize the future program based on the results of the report, which should be completed by June.

That such a review is appropriate only two years after the 1978 study is testimony to the progress made in the fusion program. Based on all evidence to date, we anticipate that progress will continue and that additional reviews will be necessary. Clearly, we cannot predict the future; but we do look forward to the continued development of magnetic fusion energy based on a carefully developed program plan.

With respect to the FY 1981 budget request, included is a 29% increase in the Applied Plasma Physics subprogram, for experimental tests of fusion concepts which are alternates to tokamaks

and mirrors; for experimental studies and modeling activities in the areas of tokamak, mirror, alternate concepts, and general fusion theory; and for initial operation of the Fusion Plasma Research Facility (FPRF) at the University of Texas. An increase of 34% is included for the Development and Technology subprogram, which is aimed at developing the engineering and technological bases needed to design, construct and operate increasingly larger and more complex fusion reactor experiments and facilities. The increase will be used in part for tokamak and mirror Engineering Test Facility (ETF) design efforts; and to continue construction on the Large Coil Test Facility at ORNL.

Increases are also included for the Confinement Systems subprogram, for experimental operation on upgrading of both tokamak devices and experimental devices designed to test the two major confinement alternatives to tokamaks: mirror and bumpy torus. Included are funds for continuing construction of the Elmo Bumpy Torus - Proof-of-Principle (EBT-P) project, which was initiated in FY 1980 and is scheduled for completion in FY 1984. Finally, under the Planning and Projects subprogram, funds are provided for construction of three major magnetic fusion facilities: $30 million for the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory, and $7 million for the Mirror Fusion Test Facility (MFTF) at Lawrence Livermore, both scheduled for completion in FY 1982; and $22.6 million for the Fusion Materials Irradiation Test Facility (FMIT) at Hanford, initiated in FY 1979 and scheduled for completion in FY 1984.

TECHNICAL ASSESSMENT PROJECTS

The final two programs I would like to discuss are Technical Assessment Projects and University Research Support. For Technical Assessment Projects, we are requesting $21.2 million in FY 1981 (Chart XI). We have restructured the program so that it now includes the Advanced Technology Projects subprogram, which was budgeted under Basic Energy Sciences last year, as well as Assessment Projects and the Satellite Power System program.

The Assessment Projects program provides for rigorous, independent assessment of existing or proposed technological initiatives in the Department, and for examination of the base of research that underlies a broad range of energy technologies. The program also provides support in fulfilling the Director's responsibility to provide independent technical advice to the Secretary on the conduct of the agency's R&D programs, in order to help make them more effective and to avoid costly mistakes. The assessments are carried out through studies, workshops, panels and other mechanisms which allow the Department to make use of the best scientific and technical talent.

In FY 1980, we are planning assessments on such areas as the technical potential of biomass options, long-range research needs in oil shale, alternatives to silicon for photovoltaics, and the status of R&D needs associated with indirect coal liquefaction processes. Our request in FY 1981 will allow us to continue these assessments as well as to initiate new ones. Our emphasis will be on expanding technology base activities to minimize potential failures or cost overruns in the Department's high cost technology and demonstration activities. Mr. Chairman, I strongly believe the ability to fund these independent assessments outside the framework of our programs is vital to the Department's research and technology development efforts. They provide a most valuable crosscheck to help ensure that our programs are on the right track.

Our request for the Satellite Power System (SPS) assessment activity in FY 1981 is $5.5 million, the same as FY 1980. The SPS assessment program is proceeding according to plan. Through the review of current literature, analyses, and experiments, an understanding of what is known, unknown, and uncertain about SPS is being developed. Even as we near the end of the three-year assessment period, new and important information is becoming available on some of the technical problems we face.

Our FY 1981 request for SPS will allow us to complete these broad-based concept development and evaluation activities initiated three years ago. It will also allow us to begin a transition to a possible next phase if a policy decision to proceed to the next logical step in the assessment of the SPS is made.

Advanced Technology Projects is an exciting activity which is aimed at developing engineering and economic data on innovative, high risk energy concepts which have potentially very high payoffs, and which, because of their innovative nature, do not readily fit into existing Department programs. This activity also serves as a mechanism for accelerating the transition of ideas which have been shown to be feasible from an engineering standpoint to the appropriate mission-oriented project organization within the Department for further development.

Our request for this activity is $12 million, which will allow us to continue to fund a number of projects initiated in FY 1979 and FY 1980, and start some new projects. Some of the projects which have been funded and which we plan to continue in FY 1981 are shown in Chart XII. One of the most successful to date has been development of the Solar Photovoltaic Residential Energy System. A prototype for this system has been built and has exceeded performance expectations to date. This system could lead to early commercialization of a cost-competitive electricity source for residential use from solar.

UNIVERSITY RESEARCH SUPPORT

The next program I would like to discuss, Mr. Chairman, is University Research Support, for which we are requesting $14.3 million in FY 1981. Chart XIII provides a breakdown of this request.

The University Institutional Agreements program provides support for university research on longer range energy problems which in many cases cut across the individual energy technology-oriented programs supported by the Department. Support is also provided to build up new energy research capabilities at traditionally minority educational institutions. In FY 1981, we are requesting $7.7 million for this activity. Through this activity, institutional research awards are made for three years, based on unsolicited research proposals which reflect the institution's total energy research capability.

I am especially pleased, Mr. Chairman, with the second part of this program, the Minority Institutions Research Program. Initiated in FY 1978, with eight awards, the goal of this effort is to strengthen the capability of traditionally minority institutions to perform energy-related research. We also hope the program will succeed in encouraging minority students to pursue scientific and technical careers in energy-related fields. Our FY 1981 requst will also allow us to conduct a special program of research apprenticeships for high school minority students interested in pursuing scientific and engineering degrees in college. Over 500 apprenticeships will be supported at the requested level.

The third subactivity under University Institutional Agreements is a new initiative which is aimed at filling the gap between the disciplinary research supported by the Basic Energy Sciences program on a project-by-project basis, and the engineering and demonstration scale projects in the technology development programs. This activity will support multi- and interdisciplinary research teams focusing on problem-oriented basic research in areas critical to energy technologies. Close collaboration will be stressed between the programs supported and the interested energy-related industry.

The next activity, University Reactor Fuel Assistance, is a very specialized program initiated by the Atomic Energy Commission some years ago. The objective is to provide support for energy research using reactor facilities at selected universities, which are not duplicated in the National Laboratories or in private industry. Funds are provided to a small number of these reactors for fuel fabrication costs, to the extent the reactors are used for teaching and academic research. In conjunction with the Administration's policies on non-proliferation, the request will also provide for tooling and other costs in association with production of low-enriched uranium fuel elements. Finally, the request will allow resumption of support for the "sharing" of these reactors by researchers at smaller, neighboring institutions.

The final activity in this program is the University/Laboratory Cooperative Program, which was transferred to Energy Research at the beginning of FY 1980. This activity, for which we are requesting $3.8 million in FY 1981, is designed to increase the interactions and flow of information between university and National Laboratory scientists, and to increase the direct familiarity of university scientists with current developments and techniques in energy R&D. A wide variety of activities are included under this subprogram, including summer or academic year research appointments for university faculty and graduate students at participating Departmental facilities, support for student research participation, faculty institutes and short courses, and the use on a shared basis of unique laboratory research equipment and facilities. In all, 2,300 faculty and students will be involved in this program at the requested level.

CONCLUSION

This concludes my prepared testimony, Mr. Chairman, and I will be pleased to answer any questions the Committee may have.

CHART I

Office of Energy Research

Summary — FY 1981 Budget Request

(Dollars in Millions)

	Budget Authority		
	FY 1980	FY 1981	Change
General Science & Research			
High Energy Physics	$ 325.1	$ 358.8	$+ 33.7
Nuclear Physics	104.6	115.5	+ 10.9
Energy Supply R&D			
Basic Energy Sciences	229.2	259.8	+ 30.6
Magnetic Fusion Energy	355.6	403.6	+ 48.0
Technical Assessment Projects	13.5	21.2	+ 7.7
University Research Support	7.1	14.3	+ 7.2
Technical Program & Policy Analysis	2.1	2.0	— 0.1
Multiprogram General Purpose Facilities	0	60.3	+ 60.3
Total OER	$1,037.2	$1,235.5	$ + 198.3

CHART II

GPF Budget Summary
($ Millions)

	BA	TEC
Buildings	26.6	60.8
Utilities	26.2	53.0
ES&H	7.5	8.5
Total	60.3	122.3

[illegible]

CHART III

Office of Energy Research
Organizational Changes

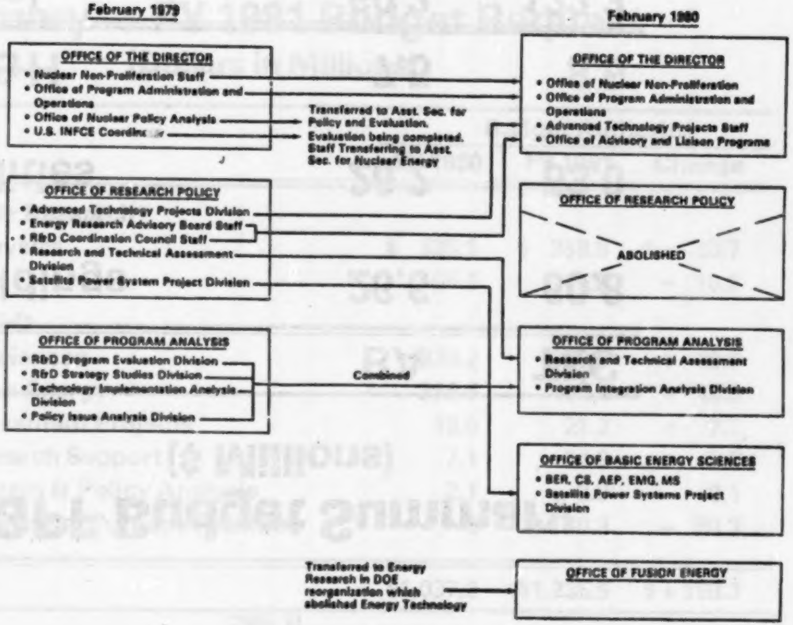
February 1979
OFFICE OF THE DIRECTOR
• Nuclear Non-Proliferation Staff
• Office of Program Administration and Operations
• Office of Nuclear Policy Analysis
• U.S. INFCE Coordinator
OFFICE OF RESEARCH POLICY
• Advanced Technology Projects Division
• Energy Research Advisory Board Staff
• R&D Coordination Council Staff
• Research and Technical Assessment Division
• Satellite Power System Project Division
OFFICE OF PROGRAM ANALYSIS
• R&D Program Evaluation Division
• R&D Strategy Studies Division
• Technology Implementation Analysis Division
• Policy Issue Analysis Division
Transferred to Asst. Sec. for Policy and Evaluation.
Evaluation being completed. Staff Transferring to Asst. Sec. for Nuclear Energy
Combined
Transferred to Energy Research in DOE reorganization which abolished Energy Technology
February 1980
OFFICE OF THE DIRECTOR
• Office of Nuclear Non-Proliferation
• Office of Program Administration and Operations
• Advanced Technology Projects Staff
• Office of Advisory and Liaison Programs
OFFICE OF RESEARCH POLICY
ABOLISHED
OFFICE OF PROGRAM ANALYSIS
• Research and Technical Assessment Division
• Program Integration Analysis Division
OFFICE OF BASIC ENERGY SCIENCES
• BER, CS, AEP, EMG, MS
• Satellite Power Systems Project Division
OFFICE OF FUSION ENERGY

CHART IV

Office Of Energy Research

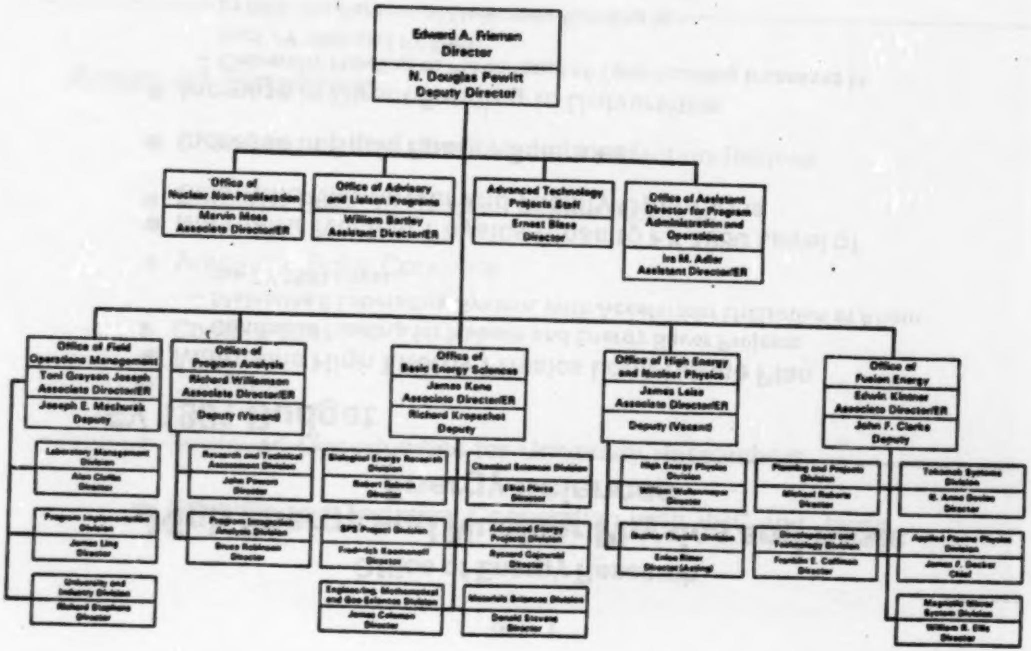
Edward A. Frieman
Director
N. Douglas Pewitt
Deputy Director
Office of Nuclear Non-Proliferation
Marvin Moss
Associate Director/ER
Office of Advisory and Liaison Programs
William Bartley
Assistant Director/ER
Advanced Technology Projects Staff
Ernest Blase
Director
Office of Assistant Director for Program Administration and Operations
Ira M. Adler
Assistant Director/ER
Office of Field Operations Management
Toni Grayson Joseph
Associate Director/ER
Joseph E. Machurek
Deputy
Laboratory Management Division
Alan Claflin
Director
Program Implementation Division
James Ling
Director
University and Industry Division
Richard Stephens
Director
Office of Program Analysis
Richard Williamson
Associate Director/ER
Deputy (Vacant)
Research and Technical Assessment Division
John Powers
Director
Program Integration Analysis Division
Bruce Robinson
Director
Office of Basic Energy Sciences
James Kane
Associate Director/ER
Richard Kropschot
Deputy
Biological Energy Research Division
Robert Rabson
Director
SPS Project Division
Frederick Koomanoff
Director
Engineering, Mathematical and Geo-Sciences Division
James Coleman
Director
Chemical Sciences Division
Elliot Pierce
Director
Advanced Energy Projects Division
Ryszard Gajewski
Director
Materials Sciences Division
Donald Stevens
Director
Office of High Energy and Nuclear Physics
James Leiss
Associate Director/ER
Deputy (Vacant)
High Energy Physics Division
William Wallenmeyer
Director
Nuclear Physics Division
Enloe Ritter
Director (Acting)
Office of Fusion Energy
Edwin Kintner
Associate Director/ER
John F. Clarke
Deputy
Planning and Projects Division
Michael Roberts
Director
Development and Technology Division
Franklin E. Coffman
Director
Tokamak Systems Division
R. Anne Davies
Director
Applied Plasma Physics Division
James F. Decker
Chief
Magnetic Mirror Systems Division
William R. Ellis
Director

CHART V

Office of Energy Research

High Energy and Nuclear Physics and Basic Energy Sciences

FY 1981 Budget

- Maintains High Energy Physics Long-Range Plan
  - Continued Funding for Isabelle and Energy Saver Projects
  - Maintains 3 Laboratory System, with Accelerator Utilization at About the FY 1980 Level
- Maintains Nuclear Physics Close to FY 1980 Level of Scientific Manpower and Facility Operations
- Increase in Basic Energy Sciences
- Increase in Direct Funding to Universities
  - University Funding as Percentage of Total Funding Increases in both FY 1980 and FY 1981
  - In BES, the Percent of University Funding is:

FY 79 Actual	FY 80 Est.	FY 81 Target
24%	27%	29%

[illegible]

CHART VI

Office of Energy Research

Areas of Emphasis

- Chemistry of Coal, Particularly Liquefaction-Related
- Research Basic to Nuclear Waste Isolation
- Advanced Solar Concepts
- Combustion
- Catalysis
- Improved Opportunities for University Researchers
- Scientific and Technical Cooperation with PRC and Japan

[illegible]

CHART VII

Office of Energy Research Programs

New Starts

- New Initiative in University Interdisciplinary Research ($3.0M)
- Multi-Program General Purpose Facilities ($60.3M)
- Tevatron - Phase I Construction ($\bar{P}P$ Colliding Beams)
  - Total Cost $39.5M, $2.0M Requested in FY 1981
- Argonne Tandem Linac Construction Project (ATLAS) for Heavy Ion Research
  - Total Cost $ 6.9M, $ 4.0M Requested in FY 1981

ARSS-21634 1/11

CHART VIII

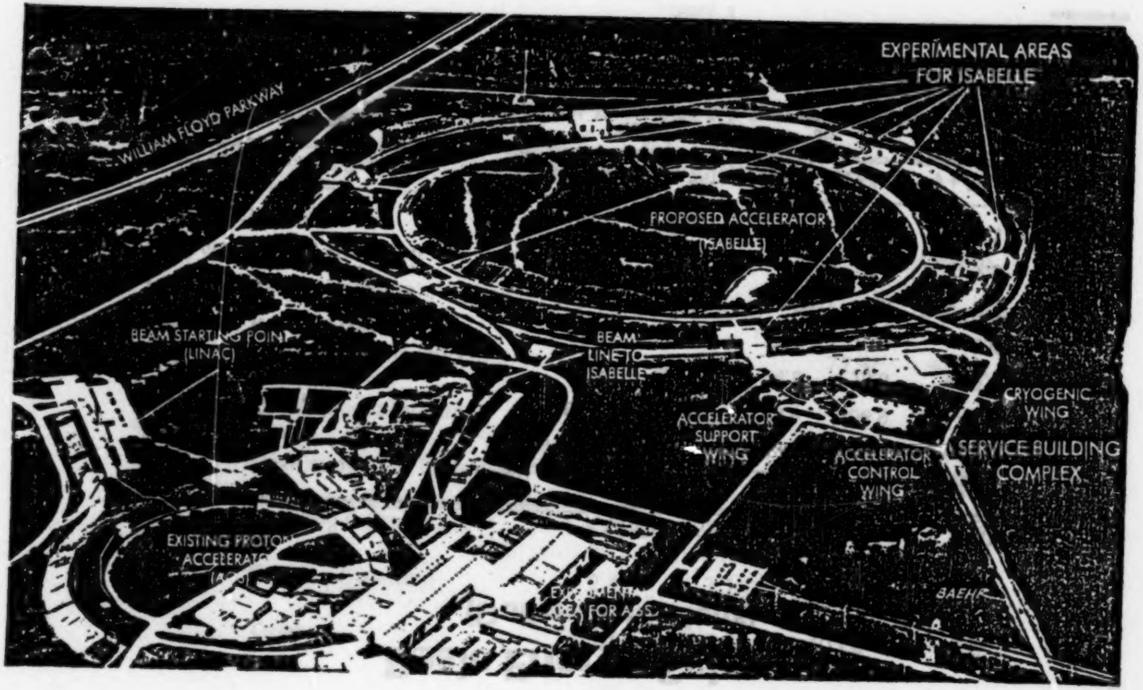
EXPERIMENTAL AREAS
FOR ISABELLE
WILLIAM FLOYD PARKWAY
PROPOSED ACCELERATOR
(ISABELLE)
BEAM STARTING POINT
(LINAC)
BEAM
LINE TO
ISABELLE
CRYOGENIC
WING
ACCELERATOR
SUPPORT
WING
ACCELERATOR
CONTROL
WING
SERVICE BUILDING
COMPLEX
EXISTING PROTON
ACCELERATOR
(AGS)
EXPERIMENTAL
AREA FOR AGS
BAEHR

CHART IX

Basic Energy Sciences

(Dollars in Millions)

	FY 1980		FY 1981		Change	
	B/A	B/O	B/A	B/O	B/A	B/O
Nuclear Sciences	$ 32.0	$ 32.7	$ 34.8	$ 33.8	$+ 2.8	$+ 1.1
Materials Sciences	97.0	108.2	99.9	106.9	+ 2.9	− 1.3
Chemical Sciences	65.1	68.0	74.5	75.3	+ 9.4	+ 7.3
Engineer., Math. & Geosci.	21.3	21.8	30.7	29.3	+ 9.4	+ 7.5
Advanced Energy Projects	5.2	5.3	8.3	8.0	+ 3.1	+ 2.7
Biological Energy Research	6.3	6.4	9.2	8.8	+ 2.9	+ 2.4
Program Direction	2.3	2.3	2.4	2.4	+ 0.1	+ 0.1
Total Basic Energy Sciences	$229.2	$244.7	$259.8	$264.5	$ + 30.6	$ + 19.8
Total FTP Staff Years	53		56		+3	

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CHART X

Magnetic Fusion Energy
Program Budget by Subprogram
FY 1981
($ BA in Millions)

	FY 1979	FY 1980	FY 1981	Change Over FY 1980	% Change
Applied Plasma Physics	59.1	56.2	72.5	+16.3	+29
Confinement Systems	98.5	113.8	131.3	+17.5	+15
Development & Technology	63.1	58.6	78.8	+20.2	+34
Planning & Projects	132.0	123.9	117.9	- 6.0	- 5
Program Direction	2.4	3.1	3.1	0.0	0
Total	355.1	355.6	403.6	+48.0	+13

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CHART XI

Technical Assessment Projects

(Dollars in Millions)

	FY 1980		FY 1981		Change	
	B/A	B/O	B/A	B/O	B/A	B/O
Assessment Projects	$2.5	$ 2.5	$ 3.2	$ 3.2	$ + 0.7	$ + 0.7
Operating Expenses						
Solar Powered Satellite	5.5	6.0	5.5	5.5	—	−0.5
Operating Expenses	5.0	5.5	5.5	5.5	+ 0.5	—
Capital Equipment	0.5	0.5	0	0	−0.5	−0.5
Advanced Technology Projects	5.0	5.1	12.0	11.3	+ 7.0	+ 6.2
Operating Expenses						
Program Direction	0.5	0.5	0.5	0.5	—	—
Operating Expenses						
Total, Technical Assessment Projects	$13.5	$14.1	$21.2	$20.5	$ + 7.7	$ + 6.4
Total FTP Staff Years	12		13		+ 1	

CHART XII

Advanced Technology Projects

- RF Heating of Tar Sands and Shale Oil
- Demonstration of Room Temperature High Energy Density Lithium Battery
- Development of Solar Photovoltaic Residential Energy System
- Application of a Solar Photochemical Water Splitting Catalyst
- Demonstration of Rapid, Low-Cost Production of Ethanol from Sugars
- Demonstration of Long Lifetime Hydrocarbon Lubricant
- Advanced Aerial Geophysical Exploration for Geothermal Resources

AR80-21634-2/11

CHART XIII

University Research Support

(Dollars in Millions)

	FY 1980		FY 1981		Change	
	B/A	B/O	B/A	B/O	B/A	B/O
Univ. Institutional Agreements	$2.3	$2.3	$ 7.7	$ 7.7	$ + 5.4	$ + 5.4
Univ. Reactor Fuel Assistance	1.7	1.7	2.5	2.5	+ 0.8	+ 0.8
Univ./Laboratory Cooperative Program	2.8	2.8	3.8	3.8	+ 1.0	+ 1.0
Program Direction	0.3	0.3	0.3	0.3	–	–
Total, Univ. Research Support	$7.1	$7.1	$14.3	$14.3	$ + 7.2	$ + 7.2
Total FTP Staff Years	5		5		0	

Senator MELCHER. Dr. Pewitt, you told us something about the program analysis function. How much of that goes beyond the programs under your control, under your direction?

Dr. PEWITT. Well, we are charged with providing technical assessments for all of the Department's energy technology programs. We have conducted a number of assessments this year which I think other program offices have considered to be helpful. An example was the study of OTEC. We are currently involved in looking at the battery and storage programs.

Most of this is in fact money for assessing programs outside of ER.

Senator MELCHER. For instance, let us state some coal R. & D. programs. Do we put the best people we have in the Department of Energy on those coal R. & D. programs?

Dr. PEWITT. I think so. I think that is the Assistant Secretary's intentions.

Senator MELCHER. Yes. How do your people feel qualified to assess, analyze that program?

Dr. PEWITT. We have a very strong technical staff that in fact serves the function of any outside group which comes in and takes a fresh look. I think of our program as more of an assistance program.

We have very much tried to shape it as an assistance program, and in fact most of our assessments that are ongoing, have been received by the programs more as assistance rather than as an effort to come in and tell them how to do things. It is the question of taking a fresh technical look at a program.

Senator MELCHER. Are you heavy on the university side of this program and the theory side, the scientific side, rather than on the engineering side of it?

Dr. PEWITT. In the offices such as Basic Energy Sciences, we are heavily into the basic side of it, there is no question about that.

However, our Program Analysis staff, we have selected and were still selecting up until a few days ago, individuals with very strong technical and research backgrounds and with a very practical bent, not a university research bent.

Senator MELCHER. I understand the President is going to instruct or has instructed Mr. Costle in EPA to ease standards on clean air in terms of coal. We will see how that comes out. I just wonder how far along the Department of Energy is on research and development to use coal with fewer problems regarding air pollution.

Dr. PEWITT. For the specifics of the coal research programs, of course, the Assistant Secretary for Fossil Energy George Furnick is the proper person to address those questions to. Our technical assessments group is currently looking at some of the problems.

What we can do is interface into a larger community of scientists to bring to light a lot of information that is already out there, but because it is so confused, it is sometimes hard to get.

A good example of that is the question of acid rain. I am no expert in acid rain, and I am not here to talk about acid rain, but we had people who knew about some work down at VPI who went to the university community and were able to access that information and make it available. It wasn't generally known in the fossil community. It is very useful information.

We provide a useful interface for the research community and the development community in a lot of cases and we access all our staff, not just the Program Analysis staff, when we do that.

Senator **Melcher**. What is your policy role vis-a-vis the Assistant Secretary for Policy Evaluation?

Dr. **Pewitt**. That was a problem area when I came to the Department of Energy about a year ago that I wasn't very clear on. However, we have now cleared that up, amd it is very straightforward.

Policy and Evaluation looks at the questions of overall energy policy and program funding, et cetera. What energy research does is provide a technical insight in an overview way. We don't tell people how to run their program, but we do provide technical oversight for the Secretary, the Undersecretary and the Deputy Secretary in the energy technology programs. We don't get into questions of long-range energy policy per se. I think there is a clear interface between energy policy, technical assessments, and energy programs, and that is the interface between ourselves and Policy and Evaluation. That is different than it was a year ago.

There is an interface, and we understand where it is.

Senator **Melcher**. Does it look like it is an improvement?

Dr. **Pewitt**. We are trying. We are trying to make it better.

Senator **Melcher**. What is the current Department of Energy attitude toward participating in the Zephyr fusion project with the West German government?

Dr. **Pewitt**. I would like to call on my colleague Dr. John Clarke who is the Deputy Associate Director of the Magnetic Fusion Energy Program.

Dr. **Clarke**. The Department is attempting to lay down a technological base for the next steps in the fusion program.

One of the questions that is of current interest is the question of what happens when you ignite a fusion plasma so that it burns by itself without external heating?

One of the German laboratories has proposed to the German government to build a device that would demonstrate the ignition process. Because of the relationship to our future program, we are interested in the outcome of that project, and therefore we are cooperating with the Max Planc Institute to provide them with technical data from our program that will be of use in their project.

The project has not yet been approved by the federal government of Germany, nor have we made any commitments to support that project in any substantive way other than furnishing technical information.

Senator **Melcher**. Is this project an essential step in the process of building an energy test facility?

Dr. **Clarke**. That has not yet been determined. We have in this country a project called the TFTR which is on schedule and will be operational in 1982. There is a body of scientific opinion that says that the TFTR will furnish all of the necessary information about the basic physical process of ignition to allow us to go to an ignited plasma, but this is a question which we have to continually reevaluate as new experimental information comes in.

Senator **Melcher**. I have a couple more questions to follow on that with regard to fusion, but do you have to wait until you get approval of the West German Government to see whether the Zephyr fusion project is going to go ahead?

Dr. **Clarke**. It is a German project, sir.

Senator **Melcher**. I mean our cooperative effort with them. Do you have to wait until the West German Government says they approve to find out whether we cooperate with them?

Dr. **Clarke**. No, sir. We are trying to provide them with as much aid as we can. The project is in the early design phase right now, and we are providing them with information on neutral beam injection which is one of the fundamental technologies for that project. In case the physical results from our experiments indicate that such a project is necessary, we will have supported it to the best of our ability.

Senator **Melcher**. For the past year, the United States has been participating in the design of an international TOKAMAK reactor. What is the policy of the administration on participating in the construction of this $1 billion international facility in contrast to building a comparable facility by ourselves?

Dr. **Clarke**. The international TOKAMAK that you are referring to is called INTOR. At this time, it is merely a design study. The INTOR was originally proposed by the Soviets as a possible way of taking the next step in the fusion program.

Because of the complications that would be involved with a 4-nation international construction project, we don't believe that it is prudent to depend on that kind of a project in our planning for the next step in the fusion program. As a result, we have established an engineering test facility design center at Oak Ridge National Laboratory. That center is providing us with the basic design for our own version of the next step in the fusion program.

It is also providing the United States input to that international TOKAMAK study. In other words, we are not relying on international projects for the future of fusion.

Senator **Melcher**. You have not been very explicit, but I assume that, because our relationship with the Soviet Government has sort of faded since Afghanistan, there is not much chance of a cooperative effort with them at this time, is that correct?

Dr. **Clarke**. I am afraid I might have been misleading by saying that the suggestion for an international TOKAMAK came from the Soviets. The International Atomic Energy Agency is sponsoring the study, and there are four nations involved—Western Europe, the Japanese, the United States, and the Soviets. This is not a direct United States/Soviet arrangement. There is always a possibility that two or three of the four nations might get together and build such a device so we are continuing on that basis. This is not a direct cooperative project with the Soviets.

Senator **Melcher**. My question was direct. Are we to assume that, because your relationship with the Soviet Government has sort of cooled since Afghanistan, there will not be much cooperative effort on this program? Is that right or wrong?

Dr. **Clarke**. Our cooperative activities with the Russians in general have been slowed down. The activity on this particular project, the design of this international TOKAMAK, is unaffected by the

Afghanistan situation because it is not a direct project with the Soviets.

Is that a sufficient answer? In general, we are slowing down our scientific cooperation work with the Soviets because of Afghanistan. This particular project is an indirect relationship and it is not affected.

Senator **Melcher**. I do not know whether you are a Soviet expert in the Department of Energy or not; but we have had a cooperative program with them on MHD. I think they still have our magnet over there.

Has our effort on that cooled down? Do you know?

Dr. **Pewitt**. The Soviet expert is not here. We might have a Soviet expert in the room.

Senator **Melcher**. Is there a Soviet expert in the room?

Dr. **Pewitt**. In general, I do know that I saw a list recently about curtailed activities with the Russians and they haven't been merely restricted. They have been severely curtailed across the board.

Senator **Melcher**. Now wait a minute. You say they have been restricted?

Dr. **Pewitt**. They have been severely curtailed across the board in the Department; we cancelled a number of visits of the Soviets to this country and have severely curtailed our visits to the Soviet Union.

Senator **Melcher**. They still have our magnet, do they not?

Dr. **Pewitt**. I understand they do. I think we would have a hard time getting an airplane in there and getting it out. It is tied into the facility.

Senator **Melcher**. And we are continuing that phase of it, of MHD research?

Dr. **Pewitt**. I don't know the specifics of what that cooperation is and whether that exchange is continuing or not, to be perfectly honest. I would have to defer that question. I just simply do not know.

Senator **Melcher**. My understanding is that an MHD channel developed here in this country is going to go over there for testing.

Dr. **Pewitt**. Yes, sir. That was developed at Argonne National Laboratory.

Senator **Melcher**. I do not think it happened, did it?

Dr. **Pewitt**. Just the magnet.

Senator **Melcher**. We halted the MHD in this case, did we not?

Dr. **Kane**. The large magnet certainly was; I'm not sure about the channel.

Senator **Melcher**. All right. We will drop that. I am advised that there is a proposed upgrade of the fusion test facilities. What is the administration's position on seeking approval of this upgrade?

Dr. **Pewitt**. We currently have that under review right now in the Department, but we have not come to a conclusion on what the Department's position is going to be. We have it under active review, and we expect to have the departmentwide review of that project sometime early next month.

Senator **Melcher**. Do you have a technical assessment of the importance of initiating this upgrade this fiscal year, 1981?

Dr. **Pewitt**. That is what we are in the process of staffing right now, and I have not yet seen the result.

Senator **Melcher**. You do not have the assessment yet?

Dr. **Pewitt**. I have not yet gotten it. It is in preparation. Perhaps Dr. Clarke can speak to it, but I haven't seen anything.

Senator **Melcher**. Now Doctor, I read your testimony here, and I think you mentioned that you thought the solar powered satellite funds were necessary.

I understand the budget provision includes the termination of the solar powered satellite program in 1981. Is that right?

Dr. **Pewitt**. I am afraid I can't be responsive to that particular question right now, sir.

Senator **Melcher**. You do not want to answer it. Were you told not to answer?

Dr. **Pewitt**. I can't be responsive to your question now, sir.

Senator **Melcher**. For the record, we understand it is terminated. Now if that is the case, is that good?

Dr. **Pewitt**. Of course, there are a number of things that we would like to do for which we probably will not be asking this committee for authorization.

Senator **Melcher**. A number of things?

Dr. **Pewitt**. I would think so.

Senator **Melcher**. How much is under your combined operation, how many millions?

Dr. **Pewitt**. We are not prepared to respond to that.

Senator **Melcher**. No. I mean as you have presented it.

Dr. **Pewitt**. How much do I have in our budget request that I am presenting to you today?

Senator **Melcher**. Yes.

Dr. **Pewitt**. The current budget request is $1,236 million.

Senator **Melcher**. Two three six?

Dr. **Pewitt**. $1,236 million.

Senator **Melcher**. One point 236, OK; that shows right here on your chart, chart I. It shows up, $200 million.

Dr. **Pewitt**. Yes, sir.

Senator **Melcher**. Now for the record, the President is going to request a reduction on that $1.236 billion and is going to request a reduction of $16 million. You come out awfully good, do you not, doctor? What is that? That is about one tenth of 1 percent, right?

Dr. **Pewitt**. I wish your number was correct.

Senator **Melcher**. You think it is more? You fear it is more?

Dr. **Pewitt**. I haven't seen the plan.

Senator **Melcher**. Let the record show the doctor does not want to answer any of these questions.

Dr. **Pewitt**. That is correct.

Senator **Domenici**. Let the record show he is a good soldier.

Senator **Melcher**. Here is what I have got so far $16½ million to come out of fusion, that will bring it down to about $400 million which is about a $41 million increase over last year. Five and a half million dollars that comes out of the solar powered satellite which scotches it completely. However, your testimony says we need to continue that and need to bring a 3-year study to end to see where we are.

Then the university institutional agreements seem to be down $3 million, but you would increase those by $5.4 million, so even with the reduction of $3 million, you still have an increase here.

Well, we will see how much else we revise these numbers, but that is all that is revised out of that $1.2 plus billion. That is a very favorable revision in your office, and we will weigh that with what else has to be revised in the President's final presentation to the Congress this year.

Senator Domenici.

Senator **Domenici**. Thank you, Mr. Chairman. I think most of my questions are directed at you, Dr. Pewitt, but it may be that one of them is for Mr. Sewell.

Let me ask you, with reference to fusion as a source of energy, what is the big difference if any between the approach in the McCormick bill and the approach of the administration?

Dr. **Pewitt**. Currently we are trying to make an assessment of the future of the magnetic fusion energy program. As I said in my opening remarks, we have a very distinguished panel reviewing this right now. We think it is an appropriate thing for the Department to do.

Given the successes of the program, I think it is our responsibility to carefully assess the future directions of the program. I am not prepared at this point to say whether we could or could not support the bill in the House at this particular time.

It calls for completion of a specific facility. One of the reasons for the review, of course, is to address questions like that, what would be technically and programatically the right timing for such a facility, or if that is the facility that one should build. We are doing our best to complete that assessment in a very timely fashion.

Senator **Domenici**. By when?

Dr. **Pewitt**. We expect the Energy Research Advisory Board to report to the Department by June 1. We think that such a comprehensive and fundamental review of a program of this significance is very timely.

Senator **Domenici**. I hope you don't take my questions to fusion to be critical. I am just very concerned that this country seems to do best when it is goal oriented. I think anyone, all of you, would agree with that. Fusion has been held out for a number of years as one of those few ultimates in terms of energy sufficiency and independence, and we quite appropriately are proceeding on a number of fronts, as you have described. Some of the scientists that I have talked to clearly support the establishment of the goal which does distinguish the McCormick bill from the present administration, and it isn't just this administration. It has been ongoing. There has been no firm goal for bringing on board the successful operation of a magnetic fusion electric generating demonstration plant by a time certain.

That is the biggest distinguishing aspect, as I understand it. I have been told by a number of people that that would be an excellent way to evaluate and push this program to its maximum.

You are not disagreeing? You are merely saying you want some intermediate steps before you draw that conclusion, is that correct?

Dr. **Pewitt**. I don't disagree that the programs work best when they have a definite goal. I do disagree that the program does not presently have a definite goal. We are reassessing that goal.

Senator **Domenici**. What is the definite goal now, doctor?

Dr. PEWITT. Our definite goal is to conduct a program in such a way as to realize the maximum potential in the future. Our current expectations and the current policy of the Department would lead us to believe that we would begin having some significant contributions from fusion after the turn of the century, about 2025, something like that. That was based on the technical progress of the program 2 years ago.

The technical progress has achieved everything predicted for it, which is quite unusual in technical programs. It is currently time for us to reassess that goal and that is precisely what we are doing. To dictate a goal doesn't make a goal happen, that is the problem. There has to be a carefully conceived program plan to back up a goal, and we are looking at that right now.

Senator DOMENICI. I am not prepared to disagree with you. I merely recognize the significant change of fact in the United States even from 2 years ago, and certainly from 5 years ago or 6.

I would assume that this Nation might be prepared to put a lot more resources into an accelerated—if feasible, and I understand you have got to come up with that aspect—fusion program now than they would have when only a few people understood the dependence of the United States on foreign fuels and the very limited number of real options for long-term security domestically and internationally in terms of energy. That is where we are now. We certainly weren't there even 5, 6 years ago into the fusion program, isn't that correct?

Dr. PEWITT. We were probably there, the realization of where we were——

Senator DOMENICI. Indeed. Facts are facts. They didn't just all of a sudden appear, but changed in the world to bring them into closer focus, as I understand it. We were growing independent before the cartel got fancy and before the countries became fragile, and I understand that.

Let me move on then and compliment you and the Department on your assessment of the need for new buildings and physical improvements in our national labs.

Was the inventory and long-term evaluation of need which you have set at $8 million?

Dr. PEWITT. That is what we said based on the study that we did. I have just spent a week out in the field. I think that figure underestimates the problem. I can't quantify that, but there are some institutional reasons why that was understated.

The fact of the matter is the Department has done so little about this problem in the past that nobody took an evaluation of these needs very seriously. I think the problem is probably larger than that by a factor of as much as two.

I think, and here again it is indicative of the problem we have had in the past, I can't even tell you what the replacement capital value of our physical plant is right now, but it is on the order of $30 billion. Just looking at the normal 40 year life turnover, one sees the magnitude of the problem being very large indeed, and this is our attempt to address it.

Senator DOMENICI. The $60 million in the budget, if it holds, is a start.

Dr. PEWITT. And just a start.

Senator **Domenici**. And whether it is at $800 million or $1.6 billion, if it is two-fold underestimated, nonetheless you are beginning the process of trying, in an orderly manner, to equip with physical improvements our national labs and to modernize them. Is that basically the goal?

Dr. **Pewitt**. Not just to modernize them—to make them fit places to work and safe places to work, and provide facilities that are adequate for the research programs we are carrying on in these laboratories.

Senator **Domenici**. That's a better way to say it. I think maybe that is my definition of modernization, but you are probably right.

Then let me ask you in terms of the Sandia. Have you been there recently?

Dr. **Pewitt**. On Saturday, as a matter of fact; I just came back from there.

Senator **Domenici**. I am impressed with the fact that we have not, since Sandia became diversified and is doing energy work, built one facility on that institution directed at the housing of that kind of technology. We are still kind of piggy-backing on what was there before it got involved in photovoltaics, in situ coal, enhanced oil extraction, solar, the largest single investment of solar technology.

I understand it is the major place for the private sector to go visit and exchange technologies in solar—8,000 visitors there last year from the private sector go there to see what's cooking, so our research money can find its way into the marketplace. There is not a facility on the corporate grounds to do that.

Dr. **Pewitt**. There is some sort of plastic bubble that they sit inside of there that is downright embarrassing to us, yes, sir.

Senator **Domenici**. I am not trying to rob Peter to pay Paul out of that $60 million, but it is not even listed in the $60 million for fiscal year 1981, is that correct?

Dr. **Pewitt**. It is not among the 1981 projects. There are a couple reasons for that. No. 1, it wasn't submitted in time for the Department's internal budget review, but after having been at Sandia and looking at the facility that they propose, and the need out there, I think we are very favorably disposed to that project for the 1982 cycle. As a matter of fact, I was very impressed with that design. It is a very, very impressive passive solar design, no incremental cost, very little operating cost for heating that design.

As a matter of fact, we are giving consideration to looking at that as perhaps a standard light lab office design for the Department, and that is under review right now. It is very impressive.

Senator **Domenici**. It would seem that if you are considering it for the standard, you ought to agree to build it.

Dr. **Pewitt**. I am not in a position to agree or disagree to building it right now. We are in fact looking very carefully at it, and we are in the process of putting together our 1982 priorities right now, but we were very, very favorably taken by the Sandia management approach to building construction.

Senator **Domenici**. Let me ask you about the $60 million. How much of that is expected to be actually spent in the year 1981 and for how many facilities. In addition, is it possible to get engineering and design work in for the Sandia facility without in any way violating the schedule?

Dr. PEWITT. No. 1, the outlays that we estimate will be associated with that $60 million are around $25 million in 1981. One of the advantages of the Sandia designs, is that they do have so much preengineering already performed. Within the priorities of the Department, I think that the projects we have in 1981 represent, even after my visit, the priorities that we would hold to as being relatively more important than projects we defer until 1982.

Senator DOMENICI. So at the worst under your recommendations, you would recommend it in 1981 to 1982, is that correct?

Dr. PEWITT. We have not finished our review, but we are certainly favorably considering it for 1982 at this time.

Senator DOMENICI. Did the geoscience building proposal for Los Alamos get in in time for review in the $800 million?

Dr. PEWITT. No. After we established this line, a lot of things started popping out of the woodwork, and that, too, was one of the facilities that was not submitted in time for our 1981 budget.

Senator DOMENICI. How did you instigate it and how could these labs not know you were doing it? How was it done? I know Sandia's problems existed for a while. I can't imagine they didn't turn in something when they have no building.

Dr. PEWITT. A lot of projects were included in a very long list. As I said, we have got about an $800 million backlog, but without a complete conceptual design to present to the gentlemen of this committee and the other Members of Congress with a definitive cost and schedules, we just couldn't go forward with a lot of these projects.

There were a lot more on the list than we possibly had room to put into any manageable budget.

Senator DOMENICI. Let me ask you, are you aware of that one now?

Dr. PEWITT. I am certainly aware of that one. I was there Friday.

Senator DOMENICI. You hit them both in the same week, Sandia and Los Alamos?

Dr. PEWITT. I hit six labs last week, in reviewing these projects with a team. We have established a general multiprogram general purpose facility working group. We are in the process right now, and are about two-thirds through, of visiting all the laboratories for our 1982 budget formulation.

Senator DOMENICI. Mr. Chairman, I hate to be so parochial, but you have covered the broad international front. You handled Germany, the building there for the geosciences, as I understand it. We have those facilities spread out over distances so that from one to another, at the furthest point, are some 14 miles apart on that lab site, is that right?

Dr. PEWITT. Yes, sir. They kept talking about 28 miles roundtrip. I never did the division on that, but that is correct.

Senator DOMENICI. They are good at—I shouldn't say that.

Dr. PEWITT. Yes, they are.

Senator DOMENICI. Just for this record, again, I am not trying to push this over one you already put on the list. I am delighted we are starting, but it is needed, from what you can tell; is that correct?

Dr. **Pewitt**. We need an awful lot, that is correct.

Senator **Domenici**. Mr. Chairman, is it appropriate to ask at this point about the progress that is being made between the Federal Government and New Mexico and the WIPP site? Is somebody going to testify specifically about this?

Dr. **Pewitt**. I'm not sure today that we have a departmental spokesman for the WIPP project.

Mr. **Sewell**. Mr. Chairman, I am Duane Sewell, Assistant Secretary for Defense Programs. I expect to have the project manager in Washington for the WIPP project here later on when I testify, and then I can answer your question.

Senator **Domenici**. You expect to have him here when?

Mr. **Sewell**. Later on when I testify before your committee, around 4 o'clock this afternoon as I understand it.

Senator **Domenici**. So we can defer it to later this afternoon?

Mr. **Sewell**. Yes. That is what I am saying.

Senator **Domenici**. I have no objection to that. I will be pleased to do that.

Dr. **Pewitt**. I would just like to mention that even though we take the responsibility for presenting the general purpose facilities line to the committee, the projects are reviewed jointly by Energy Research, Defense Programs, and Nuclear Energy and Environment, and Mr. Sewell was a part of that review.

Senator **Domenici**. Is hot dry rock in the present status of the administration request part of this or the next panel?

Dr. **Pewitt**. I think that is Dr. Davis who will be testifying.

Senator **Domenici**. When is she going to testify? Is she scheduled for today also?

Dr. **Davis**. Yes. We will be testifying as soon as the energy research program is completed.

Senator **Domenici**. I will wait for that. I have no further questions, Mr. Chairman.

Senator **Matsunaga** [presiding]. Dr. Pewitt, can you highlight for me the university research program, in particular do your plans involve additional universities?

Dr. **Pewitt**. If I may, our Associate Director of the Office of Field Operations Management will be able to respond to your question.

Ms. **Joseph**. The proposed increase for the University Institutional Agreements Program is in three categories. The first is our support for university exploratory research projects in which we select a small number of proposals from among the best universities across the country. We particularly provide support through this program for proof of principle exploratory research on longer-range energy problems.

We also have a category of Minority Institutions Research where we are supporting several minority institutions to help strengthen their capability to put them on the same caliber as the best institutions contributing to our energy program. They can then compete for support in the Department's applied research programs.

We also are requesting funds for a new minority research apprenticeship program which is a part of a Government-wide program involving six agencies and initiated by the Office of Science and Technology Policy. We are asking for $1 million for next year primarily for opportunities for minority students to participate in the Department of Energy laboratories in summer programs, and in upgrade programs.

The last category is a problem-oriented university research program proposal for $3 million that was recommended by the study group under the AAU, the American Association of Universities. It is directed primarily at problem- or goal-oriented research with a very strong tie with industry as part of the program.

Senator **Matsunaga**. As I understand it, the University of Hawaii is one of the finest in the competition being considered, is that correct?

Ms. **Joseph**. Yes, sir. We have received a proposal from the University of Hawaii and about a total of 10 other University Agreement Institutional Research proposals for next year. Out of the increase that we are requesting, we hope to be able to select 5 new proposals, the 5 would be out of the group of 10 excellent proposals that we have received, including the one from the University of Hawaii.

Senator **Matsunaga**. I would like to know the objectives of the university institutional agreements program a little more in detail. Do you happen to have it?

Ms. **Joseph**. Yes, we do. I can explain it in terms of how it originated. It was begun in the Energy Research and Development Administration by Dr. Seamans, and was mainly an effort to bring the best universities in the country and the best minds in the country to focus on solving energy research problems. What we provide is a 3-year agreement, averaging $150,000 to $200,000 a year to support the universities that come in with the most excellent proposals—usually with a multidisciplinary approach to solving longer-range energy problems. We have had, I think, some very significant successes.

The first proposal that was funded under this concept was with MIT, the Massachusetts Institute of Technology. Of the 56 projects that were funded during their 3-year period, almost half of them were picked up by the applied programs in the Department of Energy, and are being funded at a level now of $6.5 million. I think that case is an example of how you can develop the kind of multidisciplinary exploratory research which can be directly funded later by the applied programs and by industry.

Senator **Matsunaga**. There has been a cut in the proposed budget, has there not?

Ms. **Joseph**. No, sir. In the institutional agreements category we are asking for an increase, not a reduction, and it would be an increase that would permit five new institutional awards next year.

Senator **Matsunaga**. Thank you. Thank you very much.

Senator **Domenici**. Might I just ask a question about the university program?

Senator **Matsunaga**. Go ahead.

Senator **Domenici**. I won't take but a moment. First I want to commend you for the program. I think if there is one thing that we have to do, it is to commit this Nation to more basic research and commitments to basic research in physics and related fields. I am concerned because I, too, hear that while you are increased, it may not stand the cut list. Let me ask you from the other side of this, we already have some rather fantastic labs that while they are engaged for the Federal Government offer real unusual opportunity for students, for Ph. D.'s, for postdoctorate work. In this university research support program is there any re-emphasis on using existing facilities for the utilization of those laboratory technologies and equipment or is this going off in another direction?

Dr. PEWITT. Well, the University Institutional Agreements program provides funding for universities. We do have an increased request for the University Laboratory Cooperative program to enhance the interchange of individuals between universities and laboratories, and there is $1 million increase for that program in our 1981 budget submission.

Senator DOMENICI. What is the base to which you are adding a million?

Dr. PEWITT. $2.8 million in 1980.

Senator DOMENICI. So that will be $3.8 if it holds?

Dr. PEWITT. If it holds.

Senator DOMENICI. What is your understanding as to when we are supposed to find out the ultimate cut list on this $1 billion, 235 point 5?

Dr. PEWITT. I have been trying to find out all day, and I simply don't know. Someone else in the room may know when the President will transmit his budget amendments to you, but I don't know right now. I'm sorry.

Senator DOMENICI. That's all right. We ought to be able to find out as easy as you.

Thank you very much.

Senator MATSUNAGA. There are no further questions. Thank you.

Dr. PEWITT. Thank you for the opportunity to speak to you, sir.

Senator MATSUNAGA. Our next witness is the Assistant Secretary for Resource Applications, the Department of Energy, Dr. Ruth Davis.

I know that you have quite a lengthy testimony. Do you happen to have a summarized statement?

Dr. DAVIS. Yes, Mr. Chairman. With your permission, I would just like to have the detailed one inserted in the record and I would make a summary statement for a few moments only.

Senator MATSUNAGA. Fine. Without objection, your written statement will appear in the record, you may proceed, Dr. Davis.

STATEMENT OF DR. RUTH M. DAVIS, ASSISTANT SECRETARY, RESOURCE APPLICATIONS, DEPARTMENT OF ENERGY; ACCOMPANIED BY DR. STANLEY WEISS, DEPUTY ASSISTANT SECRETARY FOR INDUSTRIAL AND UTILITY APPLICATIONS AND OPERATIONS; RUDY BLACK, DIRECTOR, OFFICE OF RENEWABLE RESOURCES; BENNIE DiBONA, DIRECTOR, DIVISION OF GEOTHERMAL ENERGY; FOX PARRY, DIRECTOR, OFFICE OF ELECTRIC ENERGY SYSTEMS; AND BILL VOIGT, DIRECTOR, OFFICE OF URANIUM RESOURCES AND ENRICHMENT

Dr. DAVIS. Thank you, Mr. Chairman. I am accompanied today by Dr. Stanley Weiss, who is the Deputy Assistant Secretary for Industrial and Utility Applications and Operations.

I will also have with me my staff in the row behind me to my left, Fox Parry from the Electric Energy Systems; Bill Voigt, who is responsible for uranium activities; Mr. Rudy Black, who is responsible for alternate resources; and Mr. Bennie DiBona, who is responsible for the geothermal program.

Today I am going to make a few comments on four programs. These are uranium enrichment, uranium resource assessment, geothermal energy, and electric energy systems.

I would briefly summarize in terms of budgetary points that we are requesting $87.5 million in fiscal year 1981 for the uranium enrichment program, $35.8 million for the uranium resource assessment program, $196.7 million for the geothermal program, and $39.9 million for the electric energy systems program. I will make just a few comments on each of these four areas.

To highlight, the uranium enrichment program, as this subcommittee knows, is almost entirely funded by revenues. We will bring in over $1 billion of revenues this year. However, it does still require an appropriation of $87,541,000 for fiscal year 1981.

Our objective in this program is to supply all defense requirements for highly enriched uranium. We have also, until this month, been the sole supplier of enriched uranium for the domestic U.S. nuclear power industry, and we are still the principal supplier for non-U.S. free world utilities.

We have contracted, as of the first of this year, to supply 304 gigawatts of nuclear power. That is about 200 gigawatts with the U.S. utilities and 104 gigawatts with non-U.S. utilities.

The production plan that we have is based on supporting somewhat less than this, through 1995, and that is based on a reactor-by-reactor evaluation of reactor schedules and associated probability of completion. Our latest update as of the end of this year shows that we would be aiming for 161 gigawatts of nuclear power capacity by 1985 and 294 gigawatts by the end of 1995.

We have several improvement programs underway for our existing plants. These are the gaseous diffusion plants and the two programs we have underway which we call the Cascade improvement program and the Cascade uprating program. These are aimed at increasing our uranium enrichment capacity in the most economic way possible, with available technology.

The programs will be completed with two plants at Oak Ridge and Paducah in fiscal year 1981 and for the gaseous diffusion plant in Portsmouth, Ohio, in 1983.

In addition to improving the existing plants, we have a program underway to introduce a new technology, through construction of a gas centrifuge enrichment plant. The first production module of that plant will provide additional capacity of 2.2 million separative work units by 1988.

We will schedule the rest of that plant, which is built using a modular construction approach based on demand as we foresee it.

Going on then from uranium enrichment services to our uranium resource assessment program, we enter into a new concentrated phase of activity, in fiscal year 1981, and this will require $35.8 million, which is a decrease of $28.9 million from 1980.

Our program today is to give the first priority to the areas in the United States with the largest potential to increase our resource definition in the area of uranium. We divide the countries into areas called quadrangles, and we will complete 116 priority quadrangles in fiscal year 1980. This is 116 out of a total of around 620.

In addition, we are also investigating the sites in the United States that are considered favorable for other types of uranium deposits found in other countries or for those with higher costs.

The current estimate that we have as a result of our program to date shows 4.1 million tons of natural uranium available to us, including reserves as well as all potential resources.

In terms of reserves and probable potential resources, we estimate 2.4 million tons available of natural uranium, and that is enough to provide about 30 years of fuel for the equivalent of about 400 gigawatts of nuclear reactor electric capability.

In 1981, the national airborne radiometric survey will be completed as planned. However, we will be halting the systematic national hydrogeochemical survey and slowing down the pace of the program so that overall, the completion of the national assessment will now occur toward the end of the 1980's.

We believe that although this is somewhat of a slowdown in the previously planned program, that we are still going to be able to achieve the reliability required for our resource estimate.

The third program that I would like to discuss this afternoon is our geothermal program. In September of this year, the geothermal program in the Department of Energy was consolidated in my office and we now cover the entire range from resource definition through technology, technology demonstration, commercial demonstration, and into the marketplace activity. That program requires $196.7 million in fiscal year 1981.

Under the geothermal program we have hydrothermal resources, geopressured methane and hot dry rock. Our goal is to demonstrate the availability and the capability of these resources, and to bring them to commercial fruition as soon as is practicable.

I would point out that resource definition which confirms the commercial suitability of these kinds of geothermal resources, is a very high priority item. It is one in which Government assistance has been shown to be necessary, and we are planning for $19.4 million in this area in fiscal year 1981.

We also conduct research and technology activities which are aimed at producing the necessary energy conversion equipment and materials and we have stimulation programs to increase well productivity and geothermal energy utilization efficiency.

We also are trying to reduce the development costs through our research and technology applications, and will highlight some extremely significant technology demonstrations which are underway. The major projects that I identify here are the 5-megawatt Raft River binary pilot plant; the 3-megawatt Hawaii wellhead generator plant which will start operation early next year and will be operating at full power later in 1981; the 50-megawatt flash-steam plant to be built in New Mexico; and the 20–50 megawatt hot dry rock thermal loop to be constructed at Fenton Hill, N. Mex. We are drilling the first well for this latter plant in 1980, and in 1981 we will add a second well that is required for the system demonstration.

We have also, at the direction of Congress in its fiscal year 1980 appropriations, selected a site for a second geothermal binary demonstration powerplant. This will be a 50-megawatt powerplant at Heber, Calif.

The commercialization activities which we have underway are proceeding, at a vigorous rate. These activities include electric power demonstrations, State planning that is cost shared by the Department, initial support for direct-use projects and site-specific commercial development planning as well as our geothermal loan-guaranty program.

The loan-guaranty program now has four projects underway with guarantees totaling $43.4 million. We have applications for an additional $148 million in loan guarantees that are now being reviewed. We have asked, therefore, for a $41.982 million reappropriation in our guaranty reserved funds, and $1.284 million for program administration. We have also requested an annual guaranty authority increase of $206 million which will give us a new reserve ratio of 12 to 1. This provides the ability to guarantee follow-on loans for already started projects and provides a total guaranty authority of about $550 million if you combine our authority in fiscal year 1980 with our request for fiscal year 1981.

Senator **Matsunaga**. I wonder if you could pull that mike a little lower so we will hear you?

Dr. **Davis**. The last program I would bring to your attention this afternoon is in the area of electric energy systems, and here we have divided that program into three areas—dispersed generation and storage integration, the development of electric transmission corridor options, and the achieving of electric systems efficiency improvements.

In the last year, for example, we did in the area of dispersed generation and storage integration initiate tests to demonstrate the benefits of heating and cooling storage at 10 sites, one of these being the Olympic Village.

We are initiating a load management and distribution system test at the Tennessee Valley Authority, and will begin field tests of load management techniques with the Tennessee Valley Public Power Association system. We are also developing a family of power conditioning units for dispersed electric generation from wind, photovoltaics, storage, and fuel cell sources to accommodate DC to AC conversion.

We also are including in the program development of submarine caples for ocean thermal electric conversion plants, and for automated load management and electricity distribution.

We have as a very important part of this program, in the area of transmission, the responsibility for determining the effects of high voltage fields on plants and animals and humans. In the same program, we are developing superconducting and gas transmission cables as alternatives to overhead lines, and we are developing gas insulated equipment as an alternative to open-air electric substations.

During the current year we are initiating electric field studies on large nonhuman primates and are determining the need for expanded research on small animals.

I would point out in the last area, electric energy systems, that we have under way at Brookhaven National Laboratory the testing of the first long section, 100 meters in length, of superconducting cable. We also will be completing the battery energy storage test facility this year.

Currently, we have elements of a 1,200 kilovolt gas insulated substation undergoing tests at the Waltz Mill, Pa., testsite of the Electric Power Research Institute, and so our budget in this area is aimed at these three programs of which I have given examples of ongoing activity.

I will also mention that we have in our program, a small-scale hydro program which has been of interest to this committee in the past and for which I would be very pleased to answer questions in addition to answering them on the four programs that I have just discussed.

Thank you very much, Mr. Chairman.

[The prepared statement of Dr. Davis follows:]

Statement of

Ruth M. Davis

Assistant Secretary

Resource Applications

U. S. Department of Energy

Before the Subcommittee on Energy Research and Development

Committee on Energy and Natural Resources

U. S. Senate

Fiscal Year 1981 Authorization Hearings

March 24, 1980

INTRODUCTION

Mr. Chairman, I am pleased to have this opportunity to discuss with you the Department of Energy's (DOE) Geothermal, Electric Energy Systems Programs, and Uranium Enrichment and Uranium Resource Assessment Programs.

I should like first to submit a detailed statement for the record and then describe for you the main features of the current programs as well as our budget request for FY 1981.

I am accompanied today by Dr. Stanley Weiss, Deputy Assistant Secretary for Industrial and Utility Applications and Operations; Mr. Rudy Black, Director, Office of Renewable Resources; Mr. Bennie DiBona, Director of the Division of Geothermal Energy; Mr. Fox Parry, Director, Office of Electric Energy Systems; and Mr. Bill Voigt, Director, Office of Uranium Resources and Enrichment.

GEOTHERMAL PROGRAM

I am pleased to inform you that we have consolidated all the geothermal activities in DOE ranging from resource definition through research, development and demonstration, to putting marketplace products and services in the hands of consumers. This enables us to have a controllable product and deliverable process in place for exploiting the geothermal energy resource to what we believe is its high potential.

While this subcommittee's interests lie particularly with the research and development aspect of this program, I will also address our commercialization work in order to give a complete picture of DOE's efforts.

Geothermal resources are classified as hydrothermal, geopressured (including methane), and hot dry rock. Hydrothermal resources consist of water and steam trapped in fractured rocks or sediments at moderate or high temperatures. Geopressured resources consist of methane and water at moderately high temperatures, but at pressures higher than normal, in sedimentary formations. Hot dry rock resources consist of hot rocks at accessible depths that are relatively unfractured and contain no water, but which can pass heat to water injected and retrieved through deep wells.

I. MAJOR FUNCTION OF THE GEOTHERMAL PROGRAM

The function of the geothermal program is to provide the maximum practicable contribution from geothermal resources to our domestic energy supply consistent with economic and technical constraints. The geothermal program should be a significant contributor to our objective of a diversified energy economy adequate for national economic and security needs. To accomplish this end, the geothermal program includes the following five activities: resource assessment and reservoir confirmation, research and technology, component development, technology demonstration, and commercialization.

A. Resource Assessment and Reservoir Confirmation

The objective of this activity is to confirm the existence and commercial suitability of hydrothermal reservoirs, which are the initial and most crucial phases of bringing hydrothermal energy on line. This activity includes confirmation of the high-temperature reservoirs for electric-power production through a cost-shared drilling program with industry; it also includes assessment and confirmation of low- and moderate-temperature resources for direct heat applications through cooperative programs with state agencies and potential users. We believe that the high risk character of these activities requires cost-sharing by the Federal Government until enough reservoirs are confirmed to provide acceptance for commercial development by private industry.

This activity includes assessment and confirmation of the geopressured-geothermal resources along the Texas and Louisiana Gulf Coast. The assessment activities will delineate those geopressured aquifers which have the requisite reservoir characteristics for production of commercial quantities of methane and geothermal energy. The reservoir confirmation drilling and testing efforts include obtaining important reservoir data such as reservoir size, permeability, gas content and fluid composition to reduce the large uncertainties which presently exist on resource recoverability. The testing will be conducted in existing wells drilled for conventional gas production and new wells designed for high-rate long-term production.

The assessment of hot dry rock resources throughout the U.S. is also included under this activity. This assessment, conducted in cooperation with the USGS, consists of collecting existing temperature data from water, oil and gas wells and conducting temperature measurements in new, shallow wells. Existing geologic, geophysical and seismic monitoring data are also evaluated to determine areas of unfractured rock formations.

B. Research and Technology Activities

These activities include research in the geosciences, particularly surface exploration technology and reservoir engineering, to improve resource identification and to predict reservoir performance. In addition, geochemical engineering, materials, brine injection and well production stimulation research programs are conducted to increase equipment reliability, geothermal energy utilization efficiency, and to reduce development costs.

C. Component Development Activities

These hardware development activities are directed primarily at reducing the cost of drilling and well completions and energy conversion equipment, particularly for moderate-temperature resources where high development costs are impeding development by the private sector. In addition, environmental control equipment is being developed to reduce the adverse environmental impacts of geothermal development.

D. Technology Demonstrations

These activities include design, construction and operation of pilot-scale facilities to demonstrate new energy conversion equipment and processes and to resolve site-specific problems such as cooling water availability, injection of high-salinity brines, and cost-effective energy conversion from moderate-temperature resources.

E. Commercialization Activities

In order to encourage the private sector to develop and use hydrothermal resources for electric power and direct heat consumption, we participate in a variety of marketplace activities. Through site-specific cost-shared planning, we help to determine development potential. We examine legal, regulatory, and procedural road blocks which inhibit development and recommend means to surmount them. Two important areas of concern are the adverse socioeconomic and environmental impacts caused by development. Under our outreach program, potential users and consumer markets are identified and provided information to assist in alleviating these concerns.

The Geothermal Loan Guaranty Program is designed to assist a developer in securing private financing for commercial-scale projects. For projects that have greater technological risk factors, limited cost-shared construction and initial operation grants are available to demonstrate that facilities can operate in a dependable, economical and environmentally acceptable manner.

II. IMPORTANT ACTIONS IN THE GEOTHERMAL PROGRAM IN FY 1979 AND FY 1980

A. Managerial

As I mentioned earlier, we have consolidated all geothermal activities of the Department under the Director of the Division of Geothermal Energy, within the Office of Renewable Resources. We believe this action recognizes and supports the broad range of endeavors required to achieve marketwide use of geothermal resources.

We have also sponsored the formation of a Geothermal Advisory Panel within the Energy Research Advisory Board that reports to the Under Secretary. This panel, together with the Federal Interagency Geothermal Coordinating Council, will insure that we are receiving valuable guidance from private industry and other Government agencies on the relevance of our programs to geothermal development.

B. Resource Assessment and Reservoir Confirmation

1. Hydrothermal Resources

To identify potential hydrothermal resources for testing and possible development, at Crisfield, Maryland, we drilled and production-tested in 1979 a 5000-ft well, which discovered the first hydrothermal resource on the Atlantic Coastal Plain. In FY 1980 we will drill a second exploratory well in the Delmarva Peninsula in cooperation with a potential user. In addition, we published four state maps showing the location of probable low- and moderate-temperature reservoirs for direct heat applications as part of the state-coupled assessment program.

During FY 1979 under the industry-coupled high-temperature reservoir confirmation program in Utah and Nevada, we cooperated with industry in the drilling of 9 of the total of 21 deep wells to be drilled. In FY 1980, most of the 12 remaining deep wells will be completed. We now have data from over 400 shallow thermal gradient holes and 33 deep exploratory wells, many of which were drilled prior to the start of the program. These data are publicly available and will also support evaluation of the exploration techniques used in siting the deep exploration wells.

As part of the joint DOE-USGS regional resource assessment of the Cascades in the northwestern United States, we will drill in FY 1980 two deep exploration wells in the Mt. Hood area of Oregon.

2. Geopressured

Under the geopressured resource assessment program of the Texas and Louisiana Gulf Coast, we mapped the Wilcox and Vicksburg formations in Texas during FY 1979. Knowledge of these formations, together with the previous studies of the Frio formations in Texas and the Miocene sands in southern Louisiana, will enable us to select prime reservoirs for our drilling and testing program. In FY 1979, five additional reservoirs were identified in south Louisiana for a total of 10 now available for testing. In Texas, several promising areas in the Wilcox formation were identified and will be considered for testing along with the five previously identified reservoirs in the Frio formation.

In FY 1979, the geopressured testing activities included drilling and testing of the first well designed for long-term production in Brazoria County, Texas. In addition, two existing well tests were conducted in Louisiana. These tests indicated that the geopressured fluids were saturated with methane, although higher than expected fluid salinities were encountered, thereby reducing the gas to water ratio. We plan to drill two additional new wells in south Louisiana and a contract for a third well, also in Louisiana, will be negotiated.

C. Research and Technology

In FY 1979, with the use of hydraulic fracturing we successfully stimulated two hydrothermal wells for the 5 MWe Raft River Binary Pilot Plant in southern Idaho. This was the first attempt to stimulate geothermal well production in a fracture-dominated reservoir.

In FY 1979, we formulated and successfully tested elastomers for geothermal equipment capable of withstanding temperatures of 260°C.

D. Component Development

In FY 1979, a 500 kWe direct-contact isobutane binary power system for moderate-temperature hydrothermal applications was installed at East Mesa, California. The system will be operated through FY 1980. In addition, we installed a low-temperature pentane 100kWe binary system at a brine field near El Dorado, Arkansas. Testing of this system will also occur in FY 1980.

In FY 1980, we are continuing to operate a high-temperature downhole pump at East Mesa, California. To date, the pump has operated for more than 90 days, more than doubling previous performance experience.

E. Technology Demonstrations

In FY 1979, we completed a hydrothermal test demonstration program at the Geothermal Loop Experimental Facility in Niland, California. This provided valuable experience with high-temperature, high-salinity brines. Because of the success of this demonstration, we believe that privately-financed geothermal power plants will be built at Niland in the near future.

During FY 1980, we anticipate construction will be completed for the 5 MWe hydrothermal binary pilot plant at Raft River, Idaho. Although we have not yet reached agreement with a utility to operate the Raft River plant, we anticipate that this will be accomplished before operations are expected to begin in FY 1981.

We initiated drilling in FY 1979 of the first hot dry rock well for the 20-50 MW(thermal) loop at Fenton Hill. We also executed an agreement with the Federal Republic of Germany (FRG) for their participation in the Fenton Hill project. The FRG will provide up to $2,500,000 per year for 4 years.

F. Commercialization Activities

1. Cost-Shared Agreements: In FY 1979 a cooperative agreement was executed with Union Geothermal Company of New Mexico and Public Service Company of New Mexico to cost share the construction of a 50 MWe Flash-Steam Power Plant at the Valles Caldera of New Mexico. In January 1980, we issued the environmental impact statement for the plant and we are currently preparing the Record of Decision required under the Council on Environmental Quality's regulations. This is the first DOE-assisted commercial demonstration project for electric power production.

   During FY 1979, we also initiated 15 additional direct heat demonstration projects, bringing the total to 22 (See Chart I). To date, we have confirmed seven reservoirs for these projects, while eight were confirmed prior to DOE involvement. One well drilled near the Ore-Ida plant in Oregon reached high-temperature at 10,000 ft but was dry. The well is now being considered for well stimulation treatment or hot dry rock research.

2. Loan Guaranty: Under the Geothermal Loan Guaranty Program to date, we have approved four guaranty applications for hydrothermal projects totaling $43.4 million (See Chart II). Of the four guaranties approved, three are for electric power applications which will eventually result in total capacity of 164 MWe. The fourth project is for a direct heat application

and will result in savings of about a thousand equivalent barrels of oil per year.

3. Market Analysis and Penetration: In FY 1980, we will complete geothermal energy market assessment studies for 15 western states and 4 geothermal areas in the northeast. Four areas in the southeast will be added by the end of this year. We completed market penetration analyses for the 10 Rocky Mountain Basin and Range states and identified a potential market penetration of .1 to .5 Quads for direct heat applications. In the first quarter of FY 1980 we initiated the operation of the National Progress Monitor, a system for reporting the activities of Government and the public sector in geothermal development.

We now have an outreach program in each of four centers established in Oregon, Idaho, Utah and Maryland to provide development planning assistance and technical consultation for prospective hydrothermal resource users. As part of our outreach program, we held workshops in 10 states to determine how legislatures can foster geothermal development.

G. Problems

As I mentioned earlier, I consider the end product or set of deliverables from this program to be the maximum contribution practicable from geothermal resources to our domestic energy supply consistent with economic and technical constraints. In this vein, we have initiated a review of program goals and objectives to determine the contribution that can reasonably be expected from geothermal resources for electric power production, direct heat uses, and methane from geopressured resources. In addition, we are developing a program strategy and plan that will describe the specific steps needed to provide the final end product or deliverables.

III. FY 1981 GEOTHERMAL BUDGET REQUEST

The budget request for FY 1981 is $196.666 million (See Chart III). This includes $153.400 million for the Energy Supply Research and Development Appropriation and $43.266 million for the Geothermal Resource Development Fund. The request for Energy Supply Research and Development is an increase of $3.956 million over the FY 1980 budget. This modest increase does not indicate a static program since the reduced construction funding needs of the 50 MWe Flash-Steam Demonstration Power Plant, Hawaii 3 MWe Wellhead Generator, and Raft River 5 MWe Binary Pilot Plant will allow us to initiate new projects and expand existing programs to address some of the remaining principal technical, economic, environmental, and institutional constraints to commercial development.

A more detailed description of the FY 1981 program by budget categories follows:

A. Energy Supply Research and Development

1. Hydrothermal Commercialization

The FY 1981 budget request for Hydrothermal Commercialization is $9.024 million, an increase of $24 thousand.

This program consists of two elements: (1) planning and analysis and, (2) private sector development. Under the first element, we plan to undertake site-specific commercial development planning in 15 western states and continue second year planning support for selected areas of the Atlantic Coastal Plain. We plan to conduct state legislative reviews in six additional states (for a total of 18) to identify barriers to development and assist states in developing mitigation measures. We will rely on the National Progress Monitor to assess the degree of success and to pinpoint shortfall in rate of achievement of commercialization. In addition, we will continue to provide support to the Interagency Geothermal Coordinating Council and the Geothermal Panel of the Energy Research Advisory Board.

Under the Private Sector Development element, we will conduct market penetration analyses to determine the projected size and location for geothermal markets. We plan to conduct seven to nine site-specific engineering and economic studies for direct heat applications. In addition, we will provide support to the four technical assistance centers to aid prospective resource developers and to broaden our information dissemination activities relating to utilization opportunities.

2. Hydrothermal Resources

The FY 1981 budget request for Hydrothermal Resources is $53.0 million, a decrease of $8.4 million.

Four more states (for a total of 31) will be included in the state-coupled program to identify geothermal reservoirs of low- and moderate-temperatures suitable for direct heat applications.

Because the risks inherent in exploratory drilling have been identified as the most significant barrier to the development of low- and moderate-temperature resources, we plan to initiate a user-coupled reservoir confirmation program in FY 1981 similar to the industry-coupled reservoir confirmation program for high temperature resources.

We plan to phase out the industry-coupled high-temperature reservoir confirmation program in Utah and Nevada as previous commitments are fulfilled and the National Energy Act tax incentives take effect.

In FY 1981, we will continue the reservoir confirmation drilling and construction activities for the 22 direct heat hydrothermal demonstration projects initiated in FY 1978 and FY 1979. In addition, we will initiate two new projects to demonstrate the use of geothermal energy for energy-intensive industrial processes.

The environmental control technology program will be expanded to include seismic monitoring in areas presently under development. We also will continue our efforts to develop a system to monitor compaction and subsidence at depth and initiate new research programs to develop cost-effective methods of controlling liquid and gaseous effluents.

We plan to complete construction and initiate operation of the Hawaii 3 MWe Wellhead Generator and the 5 MWe Raft River Binary Pilot Plant will be operated at maximum capacity to collect technical and cost information. Final design for the 50 MWe Flash-Steam Demonstration Plant will be completed and construction will be well underway during FY 1981.

3. Geopressured Resources

The FY 1981 budget request for Geopressured Resources is $36 million, unchanged from FY 1980.

To reduce the uncertainties of resource recoverability, we plan on drilling three new wells designed for high-rate long-term production testing in the optimum areas identified in the geopressured resources assessment program. We will initiate testing of these wells and continue long-term testing of the four wells drilled in FY 1979 and FY 1980. In addition, we will re-enter and test three other wells previously drilled for conventional gas exploration which penetrated geopressured aquifers. In conjunction with this testing, we will assess the possible adverse environmental effects of sustained high-volume production and disposal of brines.

4. Geothermal Technology Development

The program consists of two elements: Hot Dry Rock and Component Development. The budget request for Hot Dry Rock is $14 million, a decrease of $1.0 million, and for Component Development $39.0 million, an increase of $13.0 million.

a. Hot Dry Rock

In FY 1981, we will complete the drilling of the second well required for the 20-50 megawatt thermal loop at Fenton Hill, New Mexico, hydraulic fracturing will be used to construct the downhole heat exchange area and construction of the surface facilities will begin. We will also provide support to the equipment development program required for high-temperature operations.

We plan to select a second hot dry rock site with different geologic characteristics than Fenton Hill for extraction experiments.

b. Component Development

Drilling and Completion Technology: We will continue to develop more effective conventional rotary drilling equipment and materials such as drill bits, downhole motors, drilling fluids and completion equipment to reduce the costs of drilling in hostile geothermal environments. In addition, we plan to conduct systems engineering and development of advanced drilling concepts.

Stimulation: We will conduct up to six field stimulation experiments in higher-temperature reservoirs. We will also support research and development of high-temperature hydraulic fracturing equipment and materials to support the stimulation experiments and we will investigate the interactions between hot geothermal formations and various acids used to dissolve calcium carbonate and silica in the well bore and formations.

Energy Conversion: We plan to test the 500 kWe skid-mounted moderate-temperature (isobutane) binary power system employing direct-contact heat exchangers at East Mesa, California, and a 100 kWe low-temperature (pentane) direct-contact power system at El Dorado, Arkansas. We will support the design and construction of a high-efficiency gravity-head binary power system, employing a downhole heat exchanger to increase efficiency of transfer and a thermal siphon effect to eliminate mechanical feed pumps.

Geochemical Engineering and Materials: We will address site-specific problems plaguing developers such as production well plugging due to calcuim carbonate scale buildups, silica and heavy-metal sulfide plugging of surface lines, fouling of heat exchangers, and plugging of reinjection wells.

Emphasis will be given to non-metallic materials research. We will field test high-temperature cements for well completions and reinforced polymer concrete pipe and concrete-lined pressure vessels for scale-control in surface equipment. We will also fabricate and test high-temperature elastomeric seals for down-hole pumps, motors, and stimulation equipment and metallic seals for very high-temperature applications.

Geosciences: Field tests of several geophysical exploration techniques will be conducted in areas where geothermal development has occurred to validate the techniques with actual production history. In reservoir engineering, we will develop and validate computer models for predicting reservoir performance. We will also develop high-temperature logging tools and cables in order to obtain the much needed reservoir data for field expansion. In addition, we will continue our efforts to develop logging interpretation techniques which are more suited to geothermal geologic formations.

B. Geothermal Resources Development Fund

The $43.266 million requested for the Geothermal Resource Development Fund includes $41.982 million for reappropriation of the Guaranty Reserve Fund, and $1.284 million for program administration. We have requested an annual guaranty authority of $206 million which establishes a new reserve ratio of 12:1.

Based on projects already identified, we anticipate that there could be loan guaranties granted for at least 3 new electric projects with a total capacity of 164 MWe. We also hope to guaranty seven direct heat projects that would displace a total of 0.7 million equivalent barrels of oil per year.

IV. 50 MWe GEOTHERMAL BINARY DEMONSTRATION POWER PLANT

In its FY 1980 Appropriation, the Congress directed the Department (DOE) to select within 3 months a site for a 50 MWe Geothermal Binary Demonstration Power Plant and to proceed without further delay to develop such a plant. We have evaluated all the known moderate-temperature resources and selected the Heber, California, reservoir as the best site that can potentially meet all of the objectives of a 50 MWe binary demonstration power plant. We have determined that a utility group is interested in co-funding the plant.

V. PRESENT HEALTH OF THE GEOTHERMAL PROGRAM

My assessment of the Geothermal Program at this time shows it is staffed by highly competent and motivated individuals. The management action we recently took of combining the two DOE geothermal programs into one organizational entity in my office was a much needed step: it allows for a more productive and more cohesive planning and implementation effort. It also removes the "nuisance" time which had to be spent on the interface between the two previously separate programs.

However, I believe we still need a better analysis and understanding of the program to know more explicitly the role of geothermal supplies as well as the priority which should be given to geothermal energy in the broader context of alternative fuel supply efforts, generally. We plan to delineate energy market-place "pull" and demands sufficiently that they can serve to define priorities for specific geothermal R&D, demonstration, and resources assessment projects.

We have in this DOE Geothermal program, in my view, a potential real "winner" in our alternative fuel line-up for both near and far term energy diversification. I hope you agree.

Chart I

DIRECT HEAT APPLICATIONS DEMONSTRATION PROJECTS

$ in Thousands

Project and Location	Total Project Cost	DOE Cost Share	Remarks
District Heating Systems			
Monroe City, Utah	$ 1,600	$ 924	1
Klamath Falls, Oregon	1,200	950	2
Boise, Idaho	15,300	4,926	2
Elko, Nevada	1,100	807	3
Madison County, Idaho	3,300	1,594	3
Reno, Nevada	630	410	3
Pagosa Springs, Colorado	960	686	2
Susanville, California	4,300	2,106	2
El Centro, California	2,650	1,930	3
Agribusiness			
Utah Roses - Sandy, Utah	880	459	1
Diamond Ring Ranch - South Dakota	266	177	2
Aquafarms - Mecca, California	1,090	363	2
Kelly Hot Springs - Novato, California	6,000	1,847	2
Industrial Processes			
Ore-Ida - Ontario, Oregon	4,849	2,256	Dry Hole
Holly Sugar - Brawley, California	18,000	3,921	3
Institutional Heating			
Navarro College - Corsicana, Texas	1,067	866	1
Warm Springs Hospital - Montana	2,200	626	1
Utah State Prison - Utah	540	432	3
Memorial Hospital - Marlin, Texas	660	497	1
St. Mary's Hospital - Pierre, South Dakota	460	356	1
Phillip School - Haakon, South Dakota	483	389	1
Klamath Falls YMCA - Oregon	224	191	2
TOTALS	$ 67,759	$ 26,713	

1 - Reservoir confirmed by project (7)
2 - Reservoir confirmed prior to project (8)
3 - Project wells not yet drilled (6)

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Chart II

GEOTHERMAL LOAN GUARANTY PROGRAM

Approved Loan Guaranties

$ in Millions

Project	Location	Borrower	Total Project Cost	Guaranteed Loan % of Total Proj.Cost	
Direct Heat - Food Dehydration Plant	Brady Hot Springs, NV	Geothermal Food Processors, Inc.	$ 5.4	$ 3.5	(65%)
Electric (Exploration only)	South Brawley, CA	CU I Venture	4.1	1.8	(44%)
Electric (Exploration only)	East Mesa, CA	Republic Geothermal, Inc.	17.9	9.0	(53%)
Electric (Field development)	Westmorland, CA	Westmorland Geothermal Assoc.	38.8	29.1	(75%)

DEPARTMENT OF ENERGY
GEOTHERMAL ENERGY

Chart III

(Budget Authority in Thousands of Dollars)

Subprogram	**FY 1980 Appropriation**	**FY 1981 Budget Request**	**FY 1980 - 81 Change**
Energy Supply Research and Development Appropriation			
Hydrothermal Commercialization			
Operating Expenses	$ 9,000	$ 9,024	+$ 62
Hydrothermal Resources			
Operating Expenses	36,150	42,089	+ 5,939
Capital Equipment	800	0	- 800
Plant Construction	24,450	10,911	- 13,539
	61,400	53,000	- 8,400
Geopressured Resources			
Operating Expenses	35,700	35,800	+ 100
Capital Equipment	300	200	- 100
	36,000	36,000	0
Geothermal Technology Development			
Hot Dry Rock			
Operating Expenses	14,000	13,500	- 500
Capital Equipment	1,000	500	- 500
	15,000	14,000	- 1,000
Component Development			
Operating Expenses	24,900	38,390	+ 13,490
Capital Equipment	1,100	610	- 490
	26,000	39,000	+ 13,000
Program Direction 1/			
Operating Expenses	2,044	2,376	+ 294
TOTAL Geothermal Energy - Energy Supply Research and Development Appropriation....................	$ 149,444	$ 153,400	+$ 3,956
Geothermal Resource Development Fund			
Guarantee Reserve Fund 2/	$ 0	$ 41,982	+$ 41,982
Loan Evaluation Fund	0	1,091	+ 1,091
Program Direction 1/	188	193	+ 5
	$ 188	$ 43,266	+$ 43,078

1/ FY 1980 adjusted for pay raise supplemental. This category does not appear in the FY 1981 Budget Submission. It represents the combined Program Direction budgets for Hydrothermal Commercialization and Geothermal Energy.

2/ FY 1981 represents reappropriation.

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ELECTRIC ENERGY SYSTEMS (EES)

Before turning to our FY 1981 Budget request of $39.9 million, I would like to discuss the current status of today's electric energy system. The electric energy system in the United States is one of the most complex technical systems in existence. The energy consumer in the United States has become increasingly dependent on electrical energy and, hence, upon this technically complex electric network. For example, the trend in electric energy consumption is manifested by the following figures:

Year of Sales	Electric Energy Usage in the U.S.	
	Billions of Kwhr	Growth over Previous Year
1972	1580	7.6
1976	1850	6.7
1980 (EST)	2130	2.0

Source: Edison Electric Institute; Electrical World

The decreased rate of load growth since the 1970's is due primarily to increased industrial conservation and load/price elasticity.

The electric utility industry in addition to being a principal supplier of energy to the ultimate energy consumer is also itself a major consumer of energy such as oil, gas and nuclear energy. Our growing dependence on electricity has made the capabilities, operation and technical growth of our national electric system a matter of significant importance to the Federal government.

This government's interest has been intensified by the perceived need for Federally imposed controls on the U.S. electric networks--i.e. environmental controls. Additionally, the Federal government has also directly influenced - and in some instances, controlled - the type of energy sources which it will allow the electric utility industry to use, such as plants and recent attempts to mandate substitution of coal - fired for oil - fired electric utility plants.

Federal involvement in the electric energy marketplace has thus been accepted for some time. I have asked that my office - that of the Assistant Secretary for Resource Applications - be the responsible agent within DOE for these programmatic - centered activities in the electric energy system field.

I. MAJOR OBJECTIVES AND FUNCTIONS OF EES

Our principal current function is to be the agent for the electric energy consumer by assuming the required and/or appropriate Federal responsibilities for:

1. Assuring the technical reliability and required operational integrity of the U.S. electric network as a major supplier of energy to U.S. industry and to the individual public consumer,
2. Expediting the marketplace introduction of dispersed energy generation and storage products and services by integrating them into the evolving nationwide electric network; this implies a system architect function,
3. Insuring that the electric network is so planned and configured that it can meet future demands, reliably, with lowest practicable energy losses, at acceptable costs, and in accordance with government standards and controls, and
4. Accelerating the development and availability in the electric energy marketplace of more reliable, less expensive and more capable electric system components.

To accomplish our mission EES activities have been grouped under three headings: Power Supply Integration, Power Delivery, and Generation and Storage Applications. Our efforts have concentrated on the system approach. This is essential because all the experience of the twentieth century shows that we can achieve over-all economy, efficiency and reliability only by integrating generation, transmission, distribution and utilization of electric energy into one comprehensive system.

Let me now go into greater detail about our program activities.

A. Power Supply Integration

This effort involves developing control strategies and operating procedures for complex power systems, as well as "technology specific" solutions, such as power conditioning units for photovoltaic devices.

Our strategy is to help ensure that all new sources of electric energy are integrated effectively into the electric network by:

- developing needed system methodologies in conjunction with utilities
- conducting system analyses and simulations
- conducting field tests and demonstrations

- o developing data for revising utility planning methods
- o transferring system information on new sources to utilities to hasten penetration of these sources into the power network.

The three program elements are 1) Load Management, 2) Dispersed Generation and Storage Integration, and 3) Systems Development and Control.

1. Load Management

"Load Management" is the technique for changing patterns of electricity use in order to: 1) improve system efficiency, 2) shift fuel dependency from limited to more abundant energy resources, 3) reduce reserve requirements for generation and transmission capacity, and 4) improve reliability of service to essential loads. Our program is directed toward evaluating state-of-the-art, determining future needs, developing advanced technology and demonstrating system effects and benefits.

2. Dispersed Generation and Storage Integration

Present nationwide electric energy systems are designed around central electric power generation stations. With the emergence of dispersed electric energy generation through new source technologies such as wind and solar photovoltaic, and the increased use of electric storage devices, electric energy systems need radical design changes to meet future safety and reliability standards. Present models and simulation techniques of utilities for network analysis and synthesis cannot represent these more complex systems. To ensure safe, reliable, and efficient electric power delivery from conventional (fossil, nuclear, etc.) sources when integrated with non-conventional (wind, photovoltaic, storage, etc.) energy sources, we must develop new techniques. Such techniques will help incorporate these diverse technologies into the electric system. The electric energy systems program investigates system-wide characteristics and generic aspects, aimed at cost effective large-scale utilization of new source technologies.

3. System Development and Control

This effort will lay the groundwork for improved mathematical theory and methods to analyze highly complex future systems in a shorter time than present technology allows. These future systems will include both central and dispersed generation and storage.

B. Power Delivery

The principal objectives of this program are to resolve increasing transmission corridor siting problems and specific grid-related issues, such as the effects of electric fields on living organisms. These efforts also will help integrate dispersed generation and storage technologies into the existing and future dynamic electric energy network. The main technical objectives of the power delivery program are:

- To develop transmission system designs with increased power transfer capacity per unit width of right-of-way;
- To minimize the environmental impacts of the transmission system;
- To maintain and improve transmission system' reliability; and
- To increase the energy efficiency of the network, transmission systems, and equipment.

There are four elements in this program: 1) Underground Transmission and Compact Stations, 2) High Voltage Direct Current, 3) High Efficiency Equipment and Systems, and 4) Electric Field Effects.

1. Underground Transmission and Compact Stations

Utility systems are having increasing difficulty in obtaining additional rights-of-way for overhead transmission lines. Existing underground cable technology does not provide an efficient alternative to overhead systems because of the lower capacity and relatively lower voltage ratings of state-of-the-art cable systems and the correspondingly higher cost for transmitting equal blocks of power. Similarly, a scaling up of system station components to meet the requirements of high voltage systems may not be technically feasible. Moreover, the increasing size of structure and equipment required for high voltage stations is aesthetically undesirable. Therefore, we are developing better underground cable systems and compact 1200 kV station components.

2. High Voltage Direct Current (HVDC)

The EES HVDC element has concentracted on the key components we will need if HVDC is used in network applications. Because of the absense of a practical and economical circuit breaker, a dc transmission line cannot be tapped to create networks and all present installations, are therefore, point-to-point. Since the absence of a HVDC circuit breaker penalizes dc in any technical comparison of ac and dc systems involving multi-tapped applications, the development of a HVDC circuit breaker and its application in the national electric network is of highest priority in the EES HVDC program. Our objective is to develop a dc circuit breaker and a set of HVDC design specifications to make dc a competitive option.

3. High Efficiency Equipment and Systems

This element examines utility system efficiency and promotes ways to reduce losses through new materials, new methods and analysis techniques, lower loss equipment and systems. New low loss materials are under development which are expected to reduce losses in motors and transformers by as much as 50%.

4. Electric Field Effects

DOE now sponsors a multi-disciplinary program of research to identify and characterize health effects that may be induced by electric and/or magnetic fields associated with high-voltage (HV) overhead transmission lines (both dc and 60 Hertz ac types). This is a coordinated program jointly financed and managed by the Division of Electric Energy Systems (EES), the Office of Health and Environmental Research, Bonneville Power Administration, and the Tennessee Valley Authority. DOE's research activities address both ac and dc systems and are expected by 1983 to result in a set of design specifications and guidelines for industry use. The research includes both direct biological studies and work to characterize physical-chemical perturbations to which biological systems may be exposed in the vicinity of HV transmission lines.

C. Generation and Storage Applications

Resource Applications manages projects to facilitate introduction of new generation and storage devices to the electric energy network. The work will lead to solving economic, reliability, and operating problems that impede commercialization. Specific areas include the phosphoric acid fuel cells, load leveling utility electric storage, and compressed air and underground pumped hydro storage. The two project areas are: 1) Phosphoric Acid Fuel Cells and 2) Storage.

1. Phosphoric Acid Fuel Cells

Fuel cells have characteristics which commend their use on electric utility systems, including 1) decentralized siting, 2) fuel flexibility, 3) improved efficiency that is constant over broad load ranges, and 4) environmental advantages. Once we prove economics and reliability, we expect commercialization will follow with wide industry support.

The first new dispersed electric generating source is the 4.8 MW fuel cell power plant now nearing completion in lower Manhattan. It is being supported by DOE, the Consolidated Edison Company, a consortium of other northeast utilities, EPRI and United Technologies (UTC). While major funding is through DOE, the cost sharing by the other partners is important to ultimate success and commercialization.

2 Storage

The reshaping of customer and electric system load profiles can result in 1) fuel shifting away from oil and gas, 2) greater utilization of existing capital plant, 3) improved conditions for integrating dispersed and intermittent sources of electric energy, and 4) improved reliability.

In this program both central and dispersed storage applications are being investigated to serve the necessary mix of future storage needs. These include batteries, compressed air and underground pumped hydro storage.

II. IMPORTANT ACTIONS OF FY 1979 AND FY 1980

A. Managerial

In October, 1979, the Electric Energy Systems program was transferred from Energy Technology to Resource Applications. This move emphasizes the importance of marketplace centered activities and recognizes the technological maturity of the electric energy industry.

B. Technical Accomplishments

We can cite some technical accomplishments during 1979, related to improving energy conversion efficiencies in various system components and to facilitating integration into the electric grid of new energy sources (such as solar and ocean thermal energy conversion).

Other accomplishments incorporate new technologies known for some time but which remained undeveloped (e.g. superconductivity and electrochemical fuel cells). Still others provided analytical and forecasting tools by which we can predict system performance with various novel components and under various load and usage profiles. In one way or another, all were involved with electrical system performance improvements. Accomplishments are as follows:

1. With the progress on the development of a gas-insulated power transformer, all key apparatus are under development or have reached the stage of finished prototype equipment tests for a 1200 kV gas-insulated substation. Some elements are already under test at the Waltz Mill test facility of the Electric Power Research Institute (EPRI), and others at Bonneville Power Administration facilities.
2. An ac superconducting cable test site was completed at Brookhaven National Laboratory. In 1980 the first long section of 100 meters will begin its test sequence. Likewise, an advanced superconducting generator project has completed its laboratory phase and is now in prototype development. Superconductivity is attractive because it combines higher efficiency with smaller size.
3. Construction began on a 4.8 MW fuel cell power plant. Site construction (including all equipment delivery) is scheduled to be completed in early 1980, with the acceptance test initiation set for October of that year. The site is part of the Consolidated Edison Co. system in lower Manhattan; the project is a cooperative effort of DOE with industry and EPRI.
4. A device was developed under contract to the National Bureau of Standards which will analyse non-destructively thyristor crystals prior to fabrication into ac/dc converters. This permits high performance crystals to be selected, thereby increasing conversion efficiency of this key high voltage direct current equipment. This device is now in commercial use.

5. Work was completed on the first phase of the analysis of high voltage electric field effects on living organisms. This effort is more comprehensive than prior work done by universities and industry and is designed not only to determine the effects, but also the genetic reasons for the effects. In process is further work on small rodents and large non-human primates. This work is under review by several technical peer groups and will be the basis for national standards for high voltage transmission lines.
6. Heating and cooling storage tests began in selected regions during 1979 to determine the system effects of various load management and storage scenarios. The tests will run for two years.
7. Construction of the Battery Energy Storage Test facility began during the year and is now nearing completion. This will become the test site for all advanced batteries for load leveling use on utility systems. It is located on the Public Service Electric and Gas Co. of New Jersey system, and will test DOE and EPRI funded advanced batteries. The first advanced battery (zinc chlorine) for load leveling is being purchased and will undergo testing in 1981. This will be about 100 battery modules and represent about one-tenth the capacity of a full scale battery plant for a utility company.

C. Anticipated Activities in FY 1980

We anticipate the following actions in FY 1980.

1. Initiation of load management/distribution automation system test at TVA.
2. Completion of construction for 4.8 MW fuel cell demonstration and initiation of acceptance tests.
3. Completion of construction of the Battery Energy Storage Test facility and initiation of acceptance tests in the first bay.
4. Starting of electric fields studies on large non-human primates, and determination of need for expanded research on small animals.
5. Completion of cool down tests on a superconducting cable cryostat.

D. Problems

There is significant public concern with the effects of high voltage electric fields from overhead transmission lines. Many utilities are finding that new rights-of-way for overhead transmission lines are almost impossible to obtain. It is clear that rigorous research on the effects on living organisms of such voltage fields should continue as rapidly as practical and, at the same time, future alternatives to overhead lines also must be properly pursued.

We are lacking in some of the basic data and systems tools to change today's electric network which was designed around central, predictable output, generating machines. The introduction of thousands of small, dispersed wind, solar, small-hydro and other generating sources must be successfully accomplished to meet our nation's goals to replace oil and gas by renewable resources. This will add substantially to the electric network's complexity and represents a considerable challenge. I believe that new control theory, new operating strategies, new protective schemes for both equipment and system, and new transmission and distribution circuit designs are needed to bring about the introduction and control of these new sources.

The following sections describe how our FY 1981 budget addresses these problems.

III. FY 1981 EES BUDGET REQUEST

The budget request for Electric Energy Systems is $39.9 million and represents a slight increase of $2.5 million from FY 1980 (Note Charts V and VI). The request for Power Supply Integration is an increase of $2.0 million and would improve our ability to bring into focus the issues relating to the integration of new dispersed, intermittent energy sources in systems designed around central plant sources. An increase of $1.0 million is requested for Power Delivery to make high voltage direct current a feasible, more efficient alternative to power grid reinforcement and to provide greater emphasis on determining the effects on living organisms of high voltage electric fields.

The request for Program Direction is $.9 million, a decrease of $.5 million from FY 1980 appropriations.

Another segment of the program is the Generation and Storage Applications element. Funds for these projects managed by EES are budgeted through Fossil Energy, and Conservation and Solar Energy. The two project areas are the application of phosphoric acid fuel cells and storage on utility systems.

A more detailed description of the FY 1981 program by budget categories follows:

A. Power Supply Integration

1. Load Management

The FY 1981 budget request for Load Management is $6.0 million, the same as appropriated in FY 1980. In FY 1981 this is all for operating expenses, a change from FY 1980 when $.1 million was required for capital equipment. With this level of effort, we would commence a large scale utility field test of load management techniques on the TVA system, and test reliability options by controlling selected loads.

2. Dispersed Generation and Storage Integration

The FY 1981 budget request for Dispersed Generation and Storage Integration is $10.0 million, an increase of $2.7 million.

This increase would allow exploration of the integration problems associated with new dispersed sources, and begin to place bounds on the necessary future work. This includes analysis of the system/equipment interface problems to provide safe and efficient operation for the system, the customers and public, and the dispersed equipment, and begin development of selected interface equipments. A whole new generation of protection equipment will be required to assure compatibility between the system and the dispersed sources.

Another phase of this is to coordinate systems analysis and tests with both the developers of the technology and the utilities to remove system/equipment and institutional barriers wherever possible.

3. Systems Development and Control

The FY 1981 budget request for Systems Development and control is $3.0 million, the same as FY 1980. With this budget, we would continue to develop new methodologies for dealing with system emergencies; and complete the test of advanced software to improve automatic generation controls. Also, as new intermittent, dispersed generation and storage devices are placed on today's electric network, the complexity of system controls will become many times more complex. Today's models, operating practices, and planning methods are inadequate and will require new models and mathematical representation to forecast the problems and identify potential solutions.

B. Power Delivery

1. Underground Transmission and Compact Stations

The FY 1981 budget for Underground Transmission and Compact Stations is $10.8 million in operating funds and $1.15 million in capital equipment. This is a drop of $1.6 million in operating funds and an increase of $.75 million in capital equipment.

from FY 1980. This is the result of lower hardware expenditures and a slight reordering of priorities. The hardware projects include completion of a 1200 kV surge arrestor prototype and 1200 kV circuit breaker development.

2. High Voltage Direct Current (HVDC)

The FY 1981 budget request is $4.1 million in operating funds, up $1.1 million in operating funds from FY 1980. The key elements in this effort are the development of a high voltage direct current circuit breaker and continued emphasis on increased ac/dc conversion efficiency. During FY 1981 promising advanced concepts in HVDC arc extinction will be sought and the most promising developed.

3. High Efficiency Equipment and Systems

The FY 1981 budget request is for $.8 million, an increase of $.5 million over FY 1980. This would continue the laboratory development of advanced superconducting generator concepts, incorporating them in a small prototype. It would also continue development of low loss materials for transformers and motors, and follow up on design concepts for utilizing new materials and designs for higher efficiencies in electricl equipment.

4. Electric Field Effects

The FY 1981 budget request for Electric Field Effects is $2.8 million in operating funds and $.35 million in capital equipment. This is a $.2 million increase in operating funds and $50,000 in capital equipment over FY 1980, and would enable greater emphasis to be placed on correlating the effects found in small and large animals to the predicted effects on humans.

C. Generation and Storage Applications

This EES managed work is carried out with pass-through funds. The FY 1981 budget request of $6.2 million appears in the Conservation and Solar Energy budget for utility storage applications. There is $1.0 million expected for phosphoric acid fuel cell demonstration in the Fossil Energy budget for FY 1981.

both the utility sized phosphoric acid fuel cell powerplant and utility storage toward commercialization.

Program Direction

The requested FY 1981 funds reflect the level of effort within the Office of Electric Energy Systems.

V. PRESENT HEALTH OF PROGRAM

The program is now doing very well. It is seeing the results of some well devised early R&D initiated over the past six years. For example, at Brookhaven National Labs the superconducting cable project now looks quite feasible for the commercial market in the 1980's. The cryostat is undergoing its cool down tests and a 100 meter section of cable is being built. This is expected to be the most comprehensive test of superconductivity to date and will begin later this year. Several new materials have already come from research on 1200 kV compact station equipment -- one is an insulating material developed for the 1200 kV circuit breaker and is now being introduced on lower voltage devices because of its superior performance and smaller size. Electric fields research has shown some definite high voltage exposure effects. We now need to find the safe threshold for humans. Tests on two-way communication systems show that power line carrier and telephone systems can be used to send data, and to control equipment on distribution systems; however, further improvements are required before adequate reliability levels are reached. New advanced automatic generator control software is now under test on a utility system and is showing that with this retrofit it is possible to improve plant efficiency.

In 1980, I expect to see the construction of both the 4.8 MW fuel cell power plant and the Battery Energy Test Facility completed and their acceptance tests begin. We also expect to see startup of a major test of load management and distribution automation on TVA.

I am pleased to have the responsibility for this program area in Resource Applications because I see that substantial work is needed to properly integrate new dispersed and renewable energy sources into our existing electric network. This is a marketplace impact function, which is the key emphasis and end goal for all Resource Applications programs.

This concludes my comments, Mr. Chairman and subcommittee members, I would be happy to answer any questions.

Chart V
Department of Energy
Electric Energy Systems
FY 1981 Budget Request (Budget Authorization)
(Dollars in Millions)

	1979	1980	1981
Power Supply Integration			
Operating Expenses	$ 15.4	$ 16.9	$ 19.0
Capital Equipment	.1	.1	0
Subtotal	$ 15.5	$ 17.0	$ 19.0
Power Delivery			
Operating Expenses	$ 22.6	$ 18.3	$ 18.5
Capital Expenses	1.9	.7	1.5
Subtotal	$ 24.5	$ 19.0	$ 20.0
Generation and Storage Applications			
Operating Expenses *	($ 18.9)	($ 9.5)	($ 6.2)
Subtotal	($ 18.9)	($ 9.5)	($ 6.2)
Program Direction			
Operating Expenses	$ .8	$1.4	$ .9
Subtotal	$ .8	$1.4	$ .9
Total			
Operating Expenses	$ 38.8	$ 36.6	$ 38.4
Capital Equipment	2.0	.8	1.5
Electric Energy Systems	$ 40.8	$ 37.4	$ 39.9

* funds from Fossil Energy and Conservation and Solar Energy for phosphoric acid fuel cell and utility storage application.

Chart VI
Department of Energy
Electric Energy Systems
Program Details for FY 1981 Budget
(Dollars in Millions)

	1980	1981
Power Supply Integration		
Load Management	$ 6.6	$ 6.0
Dispersed Generation and Storage	7.3	10.0
Systems Development and Control	3.0	3.0
Capital Equipment	.1	0
	$ 17.0	$19.0
Power Delivery		
Underground Transmission & Compact Stas.	12.4	10.8
High Voltage Direct Current	3.0	4.1
High Efficiency Equipment and Systems	.3	.8
Electric Field Effects	2.6	2.8
Capital Equipment	.7	1.5
	$ 19.0	$ 20.0

	1980	1981
Generation and Storage Applications	*	*

*The funds for this work are carried in the Fossil Energy, and Conservation and Solar Energy budgets. Project management resides with the Office of Electric Energy Systems.

INTRODUCTION

I. URANIUM ENRICHMENT AND URANIUM RESOURCE ASSESSMENT PROGRAMS

My emphasis in this statement will be on the major functions of the program, actions of importance which have occurred in the last year, and on the current status and thrust of our uranium enrichment and resource assessment programs. As a newcomer of just over two months to this job, I am nevertheless aware of the previous statements you have heard and of your individual and collective expertise. I hope to be the recipient of it as a major input to our programs.

II. MAJOR FUNCTIONS OF THE URANIUM ENRICHMENT AND URANIUM RESOURCE ASSESSMENT PROGRAMS

The major functions of these programs are:

(1) to supply all defense requirements for highly enriched uranium,

(2) to be the sole supplier of all needed enrichment services to domestic civilian nuclear reactors, i.e., primarily electric utility reactors,

(3) to be a principal supplier of enrichment services to non-U. S. (free world) utilities,

(4) to produce these services utilizing the most reliable, safe and cost-effective technologies available, and

(5) to develop and disseminate timely, comprehensive, and reliable information on the magnitude, availability, and economics of U. S. uranium resources and to participate in international efforts to evaluate foreign uranium resources.

Let me now address each of these functions briefly, beginning with the uranium enrichment program.

Since 1957 we have supplied all of the highly enriched uranium requirements for the naval nuclear propulsion fleet. These requirements represent about 10 percent of our current annual production. Although there has not been a new production requirement for the weapons program since 1964, if requirements were to increase in the future, they would have our highest priority.

We are the sole supplier of all enrichment services to domestic civilian reactor customers; we have been since 1957, when Shippingport started up as the first U.S. power reactor. Until recently, there has been no competition for the U.S. market. However, URENCO and EURODIF now have sales representatives in Washington seeking a share of the U.S. enrichment business. About 98 percent of the U.S. buyers are electric utilities, with the remaining 2 percent or less being used in research reactors.

To be an effective sole supplier of all enrichment services to domestic civilian reactor customers we need to (1) have credible estimates of future demands, recognizing that such estimates are difficult because this marketplace demand is highly influenced by factors outside the marketplace such as regulation and public policy; (2) produce slightly ahead of demand, believing the risk of slight oversupply to be less than undersupply, and (3) try to mitigate the periodic increases in enrichment service charges called separative work unit (SWU) charges by incorporating improved technology into our enrichment plants.

I shall deal with estimates of future demand later, and also discuss production rates.

For many reasons we want to be a principal supplier of foreign enrichment needs, including:

(1) to exert the maximum influence on foreign users to cooperate in our nuclear non-proliferation objectives and obtain enriched uranium from the U.S. rather than developing an indigenous supply capability which could also be a source of weapons material;

(2) to obtain the benefits from this program in U.S. balance of payments; and

(3) to optimize the use of available capacity in order to minimize the cost for all customers.

Indeed, as you heard last year in statements on this same subject, the President stated in 1978, "The United States must restore confidence to the world in its ability and willingness to supply enriched uranium services for commercial applications." This presumes a real concern over the image of the U.S. as a seller in the international marketplace of enrichment services.

Today we see the following non-U.S. suppliers in the international market along with their marketplace service capacity.

FOREIGN SELLERS OF URANIUM ENRICHMENT SERVICES
AND THEIR ENRICHMENT CAPACITY

Supplier	Capacity (Millions of SWU/YR)
USSR	3 to 4 available for export now
URENCO	0.4 operating; 2.0 committed; 10.0 possible by 1990
EURODIF	2.2 operating; 10.8 committed, which should be operating by 1982
COREDIF	no current capacity; 10.0 possible by 1990
Japan	0.01 operating; 0.05 committed; 2.5 possible by 1990
Brazil	no current capacity; 0.2 possible by 1985

International buyers of U.S. enrichment services are shown in Chart 1. The U.S. is experiencing a decline in its share of enrichment services for the world market. Some foreign customers have already switched from DOE to EURODIF, URENCO, and the Soviet Union, and some new business is expected to go to the non-U.S. suppliers. This concerns us. In order to reverse this trend we are visiting our foreign customers to demonstrate our desire to meet their enrichment requirements on more favorable terms than our competitors are offering.

To assure our domestic and foreign customers that the U.S. is the most economical and reliable source of enriched uranium we are working with all available technologies. Specifically, we are making major improvements to the existing gaseous diffusion technology, and aggressively developing the gas centrifuge technology. DOE is also financing R&D in Advanced Isotope Separation (AIS) Technology.

Two major expansion programs are well under way to increase U.S. uranium enrichment capacity. These are the Cascade Improvement Program (CIP) and the Cascade Uprating Program (CUP). The CIP will do so by improving efficiency of the existing gaseous diffusion plants through incorporation of the latest gaseous diffusion barrier technology. Capacity added by the CIP is obtained at a unit cost of only $17 per separative work unit (SWU) with no increase in operating costs. The CUP increases the capacity of the CIP improved plants by effectively utilizing additional electrical power. The capacity added from this program is obtained at a low cost of $54 per SWU, assuming a cost of 20 mills per kilowatt hour for power.

We are also committed to additional capacity expansion by completing the first 2.2 million SWUs of the Gas Centrifuge Enrichment Plant (GCEP) by 1988. This will permit GCEP to operate integrally with our gaseous diffusion plants, and bring to the enriched uranium marketplace the prominent advantages of the centrifuge separation process, including: (1) operation using only 5 percent of the power of the diffusion process; (2) adaptability to construction in increments consistent with market expansion; and (3) opportunity to develop and utilize second generation centrifuges with even more attractive economics when fully developed in the mid to late 1980s.

A major R&D effort is underway in Advanced Isotope Separation (AIS) Technology. One plasma separation and two laser methods are under evaluation in DOE's R&D program.

The Uranium Resource Assessment Program is necessary in order to:

- assure adequate domestic uranium supplies for current and planned light water reactors.
- provide a measure of the light water reactor capacity supportable from domestic uranium supply over the long term.
- provide a basis for timely and economic decisions regarding the development and deployment of other energy technologies, such as reprocessing, recycle of uranium and plutonium, and advanced reactor designs.
- assure other countries of the adequacy of uranium supplies to avoid premature or unnecessary use of technologies that can lead to weapons proliferation.

These activities lead to an expanded U.S. resource position, a strong capability to meet our future needs for domestic supplies, and a sound technical basis for energy planning by government and industry.

The Uranium Resource Assessment Program has provided sound, well founded data since the days of the Atomic Energy Commission, which have been the basis for long-range nuclear planning by the government, utilities and uranium producing companies. Recently this information had a key role in the Non-proliferation Alternative Systems Assessment Program (NASAP) and the International Nuclear Fuel Cycle Evaluation (INFCE).

A well coordinated uranium Resource assessment program is a proper government activity, since it conducts studies of greater scope and duration than industry programs, and it also investigates resources not actively assessed by industry, such as the more speculative resource categories.

III. IMPORTANT ACTIONS OF FY 1979 AND FY 1980

A. MANAGERIAL

To strengthen the management of the uranium enrichment program we reorganized the Office of Uranium Resources and Enrichment. We established a Division of Business and Marketing Operations to integrate budget, operational planning, pricing and marketing functions. This organizational change will provide comprehensive business support to manage uranium facilities, products, and transactions. By establishing a revolving fund to finance enrichment operations, which DOE will propose to Congress in the near future, we will further enhance that support.

B. TECHNICAL ACCOMPLISHMENTS

The major FY 1980 gaseous diffusion technical accomplishments involve the Cascade Improvement and Cascade Uprating Programs (CIP/CUP). The CIP/CUP is on schedule for completion at Oak Ridge and Paducah by the end of FY 1981.

Because of the recent 227-day strike at the Portsmouth plant, that portion of the CIP/CUP will be completed in FY 1983. By the end of FY 1980, 9.2 million SWU of the 10.1 million SWU capacity target for CIP/CUP will be installed. We foresee no technical problems in achieving the remainder of the capacity target.

Other technical support accomplishments associated with the operating, environmental and safety requirements of the operating facilities include the power recovery program, a major element of which is the demonstration project, scheduled to begin in FY 1980, to demonstrate the economic and technical feasibility of recovering waste heat from the plants. If successful, the power recovery program could reduce the diffusion plants' electric power requirements 2-6 percent (200-400 megawatts). The magnitude of the power recovery program will depend on the technical success of the FY 1980 demonstration project and the future cost of electric power.

The centrifuge development program is developing the base technology for transfer to the centrifuge and equipment manufacturers for use in the GCEP. From the centrifuge development program we have a centrifuge design which this year will be qualified for production. Extensive development and qualification tests are ongoing, and we are obtaining valuable operating experience and test data.

The GCEP project is on schedule--eight of the original 12 architect engineering firms have completed their designs. Eight major construction contracts have been completed and 10 others are underway. Eighteen offsite test and demonstration projects are being designed and built. Major procurement contracts have been placed for centrifuge machines, process equipment, electrical switchgear, transformers and some critical raw materials. About 2,400 people are now directly employed in designing and building this plant.

The initial section of the first process building, the early train, scheduled to be on-line in 1984, will provide the first operation of commercial mass-produced centrifuges. Its operation is essential to verify and qualify the manufacturing and assembly process before tens of thousands of centrifuges are manufactured.

Production of separative work from the GCEP will begin in 1987, with a capacity of 2.2 million SWUs per year available by 1988. Additional production capacity will be added in 1.1 million SWU increments as demand for enrichment services indicates the need. For planning purposes, full production of 8.8 million SWUs per year is scheduled for 1993.

The GCEP facilities will include eight centrifuge process buildings with a 2.3 million square feet of floor area. Other facilities include the Recycle/Assembly Building, and other administrative, support, test, and service facilities as required. The electrical power consumption of the GCEP will be only 135 megawatts, about 5 percent of what an equal capacity gaseous diffusion plant would require.

All of the architect-engineers have been selected for the GCEP facility on which design was begun in March 1978, and design is proceeding essentially on schedule.

The GCEP project has a construction manager/constructor on-site; site preparation is well along and foundations are being poured for the first process building. Several auxiliary buildings have been completed.

The AIS program achieved all of its technical goals during FY 1979, and progress on all three processes under development is continuing. We will select two of the processes for further evaluation depending on the success of these development efforts. Ultimately, we will select one process for scale-up to commercial production.

C. PRODUCTION

In FY 1980 the three gaseous diffusion plants will operate at an average power level of 3,011 megawatt-years, and production will be 10.6 million SWU. However, the Tennessee Valley Authority (TVA) can expand its seasonal power reductions during FY 1980. If TVA elects to take to the full option, production for FY 1980 would be 10.2 million SWU.

D. CONTRACT COMMITMENTS AND CHANGES IN ENRICHMENT SERVICE CHARGES

Contract Commitments

During FY 1979, 80 percent of DOE's long-term, fixed-commitment customers converted to the new Adjustable, Fixed-Commitment (AFC) contract, and DOE signed three new AFC contracts. As of January 1, 1980, DOE has a total contract commitment to supply 304 GWe of nuclear power of which about 200 GWe is with U.S. utilities and 104 GWe is with non-U.S. customers.

Enrichment Service Charges

Last year, the charge for uranium enrichment services increased 11.6 percent from $88.65 per SWU to $98.95 per SWU. This increase was not nearly as substantial as that in the cost of electricity required to operate our plants (24 percent) or in the cost of coal to our electric suppliers (17 percent). Moreover, we expect future increases in enrichment service charges will be less than increases in the price of coal or electricity.

E. PROBLEMS

Contract Terminations

Ten of our enrichment service customers (one domestic, nine non-U.S.) terminated their contracts with DOE in FY 1979, and additional contracts may be terminated this year because of reactor cancellations, licensing delays, desires for diversification of supply, needs to support national enrichment programs, and perceived uncertainty resulting from U.S. non-proliferation policies. We are encouraging customers who no longer need enrichment service contracts to assign their contract to other customers, if possible, rather than to terminate.

Portsmouth Strike

The local Oil, Chemical and Atomic Workers union at the Portsmouth gaseous diffusion plant struck from May 3, 1979 until December 16, 1979.

During the strike, company supervisors and managers ran the plant, thereby holding actual production loss from the strike to 500,000 SWU, or less than 4 percent of total production. The only significant impact of the strike will be a slip in the completion date of the Portsmouth plant CIP/CUP construction program from the end of 1981 to mid 1983. This schedule slip will not cause the project to exceed the total estimated cost of the project.

An issue raised by the union, outside of the normal collective bargaining negotiations, concerns health and safety issues at the plant. A DOE special panel, set up to investigate the union's allegations, has not identified any significant health and safety concerns at the Portsmouth plant. The panel will complete this investigation by the end of this month and will issue a final report.

F. RESOURCE DATA COLLECTION AND EVALUATION

In FY 1979 we made substantial progress in the data gathering phases of the National Uranium Resource Evaluation (NURE) Program and in the transition to the quantitative evaluation of resources based on that data. At the same time, we modified our program strategy to assure first priority for quadrangles with the largest potential to increase our resources. In addition, rather than using a uniform data gathering and evaluation approach, we are varying our activities as appropriate for the areas involved. We also started work on specific sites considered favorable for types of deposits found in other countries (World Class) and of intermediate grade to supplement the systematic quadrangle evaluation by focusing on specific sites with possible near term impact on the U.S. resource position.

Data gathering efforts in FY 1979 included flying 190,000 flight line miles of airborne radiometric surveys for a cumulative total of 780,000 miles of the 1,100,000 planned. We have completed 240 quadrangles out of the 621 covering the entire U.S. We took 170,000 hydrogeochemical samples and completed work on 102 quadrangles. We did over 200,000 feet of drilling in FY 1979. We completed detailed evaluation of these data, as well as assessments in the first 18 quadrangles. Quadrangle evaluation and assessment will be an increasing part of the program; we will assess 98 quadrangles in FY 1980. We have issued over 900 reports on this program.

Besides the work on NURE, we made ore reserve estimates for about 1,000 of the 1,800 deposits for which industry had provided data.

IV. FY 1981 BUDGET REQUEST

A. URANIUM ENRICHMENT ACTIVITIES PROGRAM

The DOE's FY 1981 budget for the Uranium Enrichment Activities Program is shown in Charts 2 and 3. Chart 2 displays the relative size of major program components. Chart 3 shows revenue sources to finance the major portion of the budget and our FY 1981 request. As Chart 3 shows, a significant portion of the fund requirements for the program is generated from revenues (approximately 94 percent); however, a net appropriation of $87,541,000 is necessary in FY 1981.

The budget for the Uranium Enrichment Activities Program can be best described by looking at four major program activity categories shown on Chart 4: (1) Gaseous Diffusion Operations and Support; (2) Gas Centrifuge Operations and Support; (3) Program Direction; and (4) Revenues.

GASEOUS DIFFUSION OPERATIONS AND SUPPORT

The Gaseous Diffusion Operations and Support Activity includes funds required for ongoing operation of the gaseous diffusion plants at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio, as well as funds required to assure these plants are well maintained both technically and physically. Funds are included for the purchase of cascade power, cascade operations, process and technical support, and necessary supporting services.

Consistent with our production planning and operational constraints, DOE will operate the gaseous diffusion plants at their minimum power level of 2,660 megawatts in FY 1981 and produce 9.5 million separative work units. At this power level, operational and safety margins are sufficient for cascade control. This action will result in buying less power from TVA and OVEC than required in the current contracts with them. At the budget power level, DOE would have to pay demand charges for power not purchased totaling $43,000,000 (TVA - $23,000,000; OVEC - $20,000,000). This $43,000,000 has been included in the budget. DOE is negotiating with the three power suppliers in order to reduce or eliminate the demand charge payments.

The current contract requirements for cascade power in FY 1980 are now estimated at $603,000,000 vis-a-vis an appropriation of $548,336,000. After we submitted our FY 1980 budget, (1) TVA raised power rates and (2) DOE received indications that TVA will not take all of its seasonal power reductions. Consequently, power deliveries will probably be higher than projected in the budget. In addition, OVEC has had unanticipated maintenance and pollution control financing requirements which will increase power costs in FY 1980.

The FY 1981 request for cascade power ($647,000,000) provides for a 22 percent increase in the unit cost of power over the current estimate for FY 1980, and reflects current information on the cost of power to be supplied by our three power suppliers during FY 1981. Without payment of contract demand charges for power not taken, the unit cost of power would be 12 percent above the FY 1980 estimate.

We request diffusion operating funds to cover the day-to-day operation and maintenance costs of the diffusion plants. Of the increase requested, about two-thirds will cover increased costs of wages, employee benefits, and materials. The rest will cover increased maintenance, and continue the 3-year program to reroof the diffusion plants.

Most process and technical support during FY 1981 will assure the long-term reliability and performance of the existing plants at the uprated capacity at minimum costs, mainly technical efforts to sustain long-term plant productivity by minimizing operating problems, adapting to changing conditions, and improving operations under such changing conditions. In addition, the existing plants must comply with all current and future environmental, health, safety and other policy or regulation changes. Dealing with such problems will be a significant part of our technical support. Technical support for the CIP/CUP program will help assure installation of the best possible equipment and technology during the rest of the capacity expansion programs.

Supporting services funds will allow us to continue various support activities essential to run the plants efficiently, such as: maintaining standby facilities; interplant flow of enriched uranium and other material; warehousing of uranium compounds; undertaking conceptual design and other engineering studies; and selling our services to both foreign and domestic customers.

PLANT AND CAPITAL EQUIPMENT - DIFFUSION OPERATIONS

Turning to Chart 5, the first item, Environmental Protection and Safety Modification, Phase I, is the first in a series of annual projects to bring the gaseous diffusion plants into compliance with Federal, State and local pollution control requirements concerned with disposing of solid wastes and the discharge of certain liquid pollutants.

The second item, Instrumentation for Purge Cascades and Withdrawal Areas, provides vibration, temperature, and UF_6 detection data processing instrumentation similar to instrumentation to process equipment by the Cascade Uprating Program. Proper monitoring by computer and the use of trend analysis will provide operating information to prevent catastrophic failures of critical process and support equipment.

Supervisory Control and Data Acquisition systems, the next item, will monitor the critical parts of the high voltage switchyards and the power distribution networks. (The existing systems, incorporating technologies available at the time the plants were built (25 to 30 years ago), are inadequate to meet current and future power gradients and distribution needs.)

The fourth item, Utilities Upgrading, will improve the mechanical reliability and operational efficiency of some plant utility systems not improved in the Cascade Improvement Program (CIP) or Cascade Uprating Program (CUP). Many units and systems being upgraded are approaching 40 years of service. Therefore, they are no longer reliable, and are costly to maintain.

The fifth item, UF_6 Cylinders and Storage Yards, provides for new 14-ton cylinders, cylinder handling equipment and cylinder storage yards necessary to store depleted UF_6 generated by operating the gaseous diffusion plants in a safe and environmentally acceptable way.

The sixth item, General Plant Projects, is needed to maintain the enrichment facilities in good repair, to adapt the facilities for improved production techniques, to achieve economics of operations, and to reduce or eliminate health, fire, security, and other problems. We cannot accurately identify specific work this far in advance, because operating conditions in FY 1981 will determine what work we will need.

Chart 5 also shows the capital equipment funds requested for FY 1981 to replace equipment to support the ongoing operation of the diffusion plants and equipment needed for major centrifuge development efforts. DOE now has contracts to provide product from the gaseous diffusion plants extending through 2015. Meeting these commitments will require enough money for equipment to assure uninterrupted operation of the gaseous diffusion plants.

Prior year projects requiring FY 1981 appropriations, shown on Chart 6, include five projects authorized in FY 1980: (1) Motor and Switchgear Upgrading rewinds some of the smaller sized process motors and replaces some of the process and auxiliary switchgear that were not included in the CUP program; (2) Power Recovery Demonstration Cells provide facilities to demonstrate the feasibility of recovering a portion of the power (waste heat) used in the gaseous diffusion plants; (3) Plant Facilities Security Improvements provide improved security at the diffusion plants including essential outlaying facilities serving the plants; (4) Control of Water Pollution provides facilities to reduce the discharge of pollutants and to control accidental releases of potentially hazardous or polluting materials into nearby streams; and (5) Control of Gaseous Effluents provides facilities at the Oak Ridge and Paducah plants to control the release of airborne effluents emanating from routine operations, primarily fluorides.

The final prior year item, Process Equipment Modifications, part of the Cascade Improvement Program started in FY 1971, will increase the capacity of the existing gaseous diffusion plants by about 5.5 million SWUs per year or about one-third (from 17.2 to about 22.7 million SWUs per year). The increase will come from incorporating the latest improvements in gaseous diffusion technology while not consuming additional power and with no increase in operating costs. The program, initially scheduled to be completed in FY 1981, will be completed during FY 1983 as the result of a 227-day strike at the Portsmouth plant.

GAS CENTRIFUGE OPERATIONS AND SUPPORT

Gas centrifuge operations include funds for development and demonstration, including running existing facilities, supporting construction projects to provide capability for testing and qualification of the GCEP centrifuge, and investigating the potential for improved centrifuge performance. The main thrust of the development program through FY 1981 is to provide qualified designs for the centrifuge and supporting components for the GCEP. With the startup of the Centrifuge Plant Demonstration Facility (CPDF) in 1982, the centrifuge development program is expected to peak. Then we will emphasize improving the centrifuge performance for incorporation in the later GCEP process building.

We have selected three manufacturers to provide centrifuges under initial GCEP procurement contracts; therefore, the industrial activities will shift from development emphasis to engineering and manufacturing in support of GCEP, and DOE will terminate its development technology transfer program.

Finally, our FY 1981 request includes funds for startup activities associated with GCEP, including conceptual design, special management, and miscellaneous studies by centrifuge program contractors, and the initial training of operation and maintenance personnel required to start up the first two GCEP process buildings.

PLANT AND CAPITAL EQUIPMENT - GAS CENTRIFUGE OPERATIONS

Chart 7 shows the plant and capital equipment funds requested in the FY 1981 budget for Gas Centrifuge Operations and Support.

The Enriched Uranium Production Facilities Project is to build the Gas Centrifuge Enrichment Plant (GCEP) at the DOE Portsmouth Plant site near Piketon, Ohio, to provide needed additional enrichment capacity. When completed, it will include eight process buildings, a recycle/assembly building and several plant support facilities.

The FY 1981 funds will permit continuing activities, started in prior years, including: design, expansion of vendor capacity, technical support, procurement of centrifuge machines and service modules, materials, and other GCEP components. Funds are provided to continue to build Process Building No. 1, the Recycle/Assembly Building, and centrifuge manufacturing facilities. We estimate this project will cost $5.5 billion in FY 1981 dollars.

PROGRAM DIRECTION

The FY 1981 request also includes funds to cover salaries and related benefits of the DOE Headquarters and field personnel associated with the Uranium Enrichment Activities Program, including funds for 68 DOE staff-years--49 staff-years for necessary Headquarters program management and support, and 19 staff-years at the Oak Ridge Operations Office for guards required during shipment of enriched uranium.

REVENUES

A major item is revenues, which includes the income which will accrue from enrichment services for domestic and non-U.S. customers. Our estimate is the net of advance payments by enrichment services customers in prior years. The estimate for FY 1981 provides for the sale of 10.8 million SWUs and is based on cost recovery pricing for all services performed. Also included in the estimate is approximately $110 million from the sale of depleted uranium to an Italian utility (ENEL).

B. URANIUM RESOURCE ASSESSMENT PROGRAM

Our budget request for the Uranium Resource Assessment Program is shown in Chart 8. The FY 1981 requested budget authority of $35.8 million is a decrease of $28.9 million from the FY 1980 appropriations, and reflects a somewhat lessened urgency regarding the completion of a comprehensive study of U.S. uranium resources. Reduced demand projections, and an improving resource situation can allow the deferral of decisions for large-scale commitment to advanced nuclear systems. The National Airborne Radiometric Reconnaissance Survey will be completed as planned during FY 1981, and the survey results will be open filed in FY 1982. The conduct of a systematic National Hydrogeochemical and Stream Sediment Survey will be discontinued. Future sampling will be done selectively in field sites for which geochemical data are determined to be specifically needed in order to maintain an acceptable level of geologic data upon which to base resource estimates. This approach necessitates the closeout of two of the three DOE national laboratories currently engaged in the hydrogeochemical survey. Analysis of samples collected to date will continue at one laboratory and these data will be integrated into quadrangle evaluations. Subsurface investigations will also be reduced. Although this is a departure from the previously planned program which provided a more comprehensive data base for the entire country, it is believed that the reliability of uranium resource estimates will not be excessively impacted as a result of reduced data collection activities. The pace of the program will be slowed and completion of the national assessment will be stretched 3 to 5 years beyond the 1985 date in our previous plans.

V. TECHNICAL ASPECTS OF THE PROGRAM

A. URANIUM ENRICHMENT ACTIVITIES PROGRAM

OPERATIONAL PLANNING FOR THE DOE ENRICHMENT PLANTS

A synopsis of DOE's long-range operating plan for enrichment plants is presented below.

DOE Projection of Nuclear Power Growth

The DOE Office of Uranium Resources and Enrichment (OURE) has updated its estimates of nuclear power capacity served by U.S. uranium enrichment plants. Chart 9 summarizes the current mid-range estimate. OURE estimates that 161 gigawatts of U.S. and non-U.S. nuclear power capacity with DOE enrichment services contracts will be on-line by the end of 1985. We expect on-line nuclear power capacity with DOE enrichment services contracts to increase to 227 gigawatts by 1990 and to 294 gigawatts by 1995. These estimates are 19 gigawatts lower in 1985 and 58 gigawatts lower in 1990 than presented in last year's testimony and reflect repercussions of the Three Mile Island 2 incident, announced delays and cessation of nuclear construction activities by some domestic utilities, and enrichment service contract terminations by some non-U.S. customers.

The estimate for domestic nuclear power capacity on-line through 1990 reflects a detailed examination of each reactor now in the "pipeline." The 1995 domestic estimate reflects an October 1979 mid-range projection of the Energy Information Administration (EIA) in a re-evaluation of the nuclear forecasts published in its 1979 annual report. The non-U.S. estimates were developed in a similar fashion. Each non-U.S. reactor with a DOE enrichment contract was examined in detail. Also, we made a country-by-country evaluation of formal nuclear plans through 1995 and an assessment of the likelihood of achieving these plans and the potential for the U.S. to obtain an enrichment contract.

The above estimates reflect our best guesses. Although there is a sound basis for these estimates, there is considerable uncertainty about the future, particularly about the impact of future Nuclear Regulatory Commission licensing policies, possible impact of international events (such as the loss of Iranian oil), and impact of United States non-proliferation policies. We will continue to monitor these events and revise our projections accordingly.

Requirements for DOE Enrichment Services

The requirements for DOE enrichment services corresponding to the estimated nuclear power growth are shown in Chart 10. These projections were based on the above nuclear power growth using standardized boiling water and pressurized water once-through cycle reactor models. These models reflect annual refueling schedules, as well as 18-month refueling schedules (which have higher SWU requirements). The latter was included because a significant fraction of our customers say they plan to operate with longer refueling schedules.

Chart 10 also includes U.S. Government needs, which through 1995, are expected to average 1 million SWU per year. Government users now include the Naval Reactors program, and the nuclear R&D programs.

Actions Based on the DOE Projection for Enrichment Services

The projected DOE enrichment services supply is also shown on Chart 10. Based on the DOE enrichment services projections, we have developed an operating plan to meet requirements, seeking to supply the projected requirements for enrichment services, at a transaction tails assay no greater than 0.25% U-235, while minimizing DOE-owned inventories of low enriched uranium.

We expect to be able to operate the enrichment plants at the current 0.20% U-235 tails assay until about the early 1990s. We also do not expect to have to increase the transaction tails assay above the current 0.20% U-235 level through 1995 thereby allowing customers to obtain nuclear fuel at close to minimum cost.

The low enriched uranium inventory levels as a function of time for the current operating plan are shown in Chart 11, which shows the separative work contained in DOE's inventory of low enriched uranium. As indicated, we will meet all projected requirements and maintain an inventory of at least 14 million SWUs throughout the period.

The minimum level is comprised of:

(1) A 9 million SWU working inventory to serve as a buffer between the levelized daily production of enriched uranium and the intermittent day-to-day shipments of finished product to enrichment services customers.

(2) A 5 million SWU set aside for possible use as part of U.S. efforts to improve international nuclear fuel assurances as described in the President's response to Section 104(b) of the Nuclear Non-proliferation Act of 1978.

In producing the inventory shown on Chart 11, we have assumed (except for FY 1981) that the full 8.8 million SWU GCEP capacity will be completed in 1993, and that actual electric power delivered to the gaseous diffusion plants will be only 96 percent of the planned levels. This is based on nine years of historical data and reflects reductions in contracted power deliveries in emergencies to help alleviate threatened power shortages to consumers, coal shortages at the DOE power suppliers, generator outages due to storms, etc. We have also assumed further power reductions from FY 1982-1986 in order to better balance supply of enriched uranium with forecast demand.

Sale of Depleted Uranium to Italy

DOE has contracted to sell 20,000 metric tons of 0.3% U-235 depleted uranium to the Italian electric utility, Ente Nazionale per l'Energia Ellecttrica (ENEL) for $162 million in total sales. The material will be delivered in FY 1981 and 1982 to EURODIF, the gaseous diffusion plant in Tricastin, France. Italy's nuclear power program has been delayed considerably, and ENEL will have the uranium enriched under their EURODIF contract to make it available for subsequent use.

The quantity of material in this sale represents only a small fraction of DOE's expected depleted uranium inventories through this period.

Marketing Activities

A goal of U.S. energy policy is for the U.S. to "restore confidence in its ability and willingness to supply enriched uranium services." For the United States to maintain its position as a major supplier to the non-U.S. market and as the sole supplier for the U.S. enrichment market, we must run existing enrichment facilities efficiently, undertake a timely expansion of DOE enrichment facilities, and at the same time, actively contract and market if we are to compete with the European suppliers for international customers. To accomplish this we are:

- maintaining an enrichment contracting posture which reflects customer needs, U.S. policy and current market conditions;
- promoting our service by informing existing and potential customers of DOE enrichment policies, contract terms, etc.;
- using regional foreign and domestic missions and conferences to explain DOE's contract arrangements, present capacity and expansion plans, as well as to assess potential market opportunities, prevent the loss of existing customers and establish meaningful contacts; and
- analyzing market forces, customer needs and supply/demand conditions.

With a strong contracting and marketing effort, the U.S. will continue to benefit from the uranium enrichment program in terms of balance of payments, domestic employment and significant influence on nuclear policies abroad.

During the past year our marketing staff has had many contacts with enrichment customers, both at home and abroad. DOE teams went on marketing missions in Mexico, Turkey, Egypt, Greece, Japan, Korea and Taiwan. Also, in February 1980, we held enrichment seminars with U.S. utilities in five cities from Boston to San Francisco to improve personal contacts and exchange business information.

In July 1974, because the expected capacity of the three gaseous diffusion plants was committed, the U.S. stopped contracting for enrichment services. On May 26, 1978, Secretary Schlesinger announced that DOE was ready to accept new orders for enrichment services with domestic and non-U.S. customers. This announcement followed congressional hearings and congressional approval of a revision to the Uranium Enrichment Services Criteria recognizing that DOE enrichment capacity would be expanded by building the 8.8 million SWUs per year Gas Centrifuge Enrichment Plant at Portsmouth, Ohio. By re-entering the enrichment services market, the U.S. has enhanced the credibility of its fuel assurances to those nations abiding by appropriate non-proliferation obligations.

The new Adjustable, Fixed-Commitment (AFC) contract for uranium enrichment services made available in July 1978, has been well received. The AFC contract provides greater scheduling flexibility than the more restrictive Long-Term, Fixed-Commitment contract. About 80 percent of the customers who previously held the Long-Term, Fixed-Commitment contract have converted to the AFC contract. We now have 174 AFC contracts, including three new ones. The AFC contracts cover the fuel requirements for about 170 million kilowatts of nuclear generating plant capacity. The total of all types of DOE contracts covers about 305 million kilowatts of nuclear power. Also during FY 1979 we had 10 customers terminate their enrichment contracts because of cancellation of their reactor projects, desire to support a European enrichment supplier for nationalistic reasons or for diversification of supply, and a feeling of uncertainty and lack of assurance about being granted a license to export enriched uranium under the terms of the Nuclear Non-proliferation Act of 1978.

The Adjustable, Fixed-Commitment contract has already accomplished one of its main objectives: it has allowed customers to reschedule firm deliveries to a later date, in line with actual needs. Before the AFC contracts were signed last year, there were 72.3 million separative work units (SWUs) scheduled for delivery to fixed-commitment customers from FY 1980 through FY 1984. After the AFC conversions and schedule adjustments, only 40.7 million SWUs remained and 31.6 million SWUs were delayed beyond FY 1984. A number of utilities are pooling SWUs in order to match purchases with real demand. The AFC contract permits the customer to use surplus SWUs delivered under another DOE contract instead of ordering "new" SWUs under his own AFC contract. Thus, the AFC contract seems to be working.

B. URANIUM RESOURCE ASSESSMENT PROGRAM

NATIONAL URANIUM RESOURCE EVALUATION

The National Uranium Resource Evaluation (NURE), a phased program of data gathering and evaluation, begun in 1974, will be completed in the late 1980s. NURE seeks to develop basic information to show favorable geologic areas for the occurrence of uranium deposits. These data provide the basis for estimating contained resources, by analogy to environments where known deposits have been studied in detail. Although the program so far has been heavily oriented toward data gathering, a significant part of the U.S. will also have been evaluated and resource estimates made by the end of FY 1980.

Since NURE is a complex and widespread program, it involves numerous organizations and individuals with a variety of expertise. Our principal contractor is the Bendix Field Engineering Corporation. The United States Geological Survey is involved in this assessment and participates in a number of other activities. Also, State geological surveys, universities and private firms are involved.

The NURE program is planned, carried out and reported on the basis of the National Topographic Map System Quadrangles, which divides the nation into some 621 quadrangles which, in the conterminous U.S. are 1° of latitude by 2° of longitude and average about 5,700 square miles in area.

NURE's data gathering has concentrated on a systematic natiowide airborne radiometric reconnaissance survey and a similar hydrogeochemical and stream sediment reconnaissance survey. It also includes surface and subsurface geologic investigations. The data from the various surveys and investigations are studied, supplemented by additional field studies as warranted, and evaluated to identify areas favorable for uranium deposits. A detailed comparison is made of the geologic features of these areas to areas with known types of uranium deposits. The survey results and the study are published as a folio for each quadrangle, which is the basis for quantitative assessments of the resources of each favorable geologic areas.

The data gathering is well underway--generating a substantial data base which we are now evaluating. Future efforts will increasingly involve evaluation; hence, more quantitative assessment results will be available. Accomplishments through FY 1979 included:

- Completing over 780,000 of the planned 1,100,000 flight line miles to be covered by the national aerial radiometric reconnaissance survey,
- Collecting stream and sediment samples covering over 1,900,000 square miles,
- Completing over 212,000 feet of drilling and approximately 300,000 feet of logging of industry non-uranium drilled holes,
- Developing and transferring to industry a direct uranium borehole logging system,
- Placing an estimated 950 reports on open file, including 90 radiometric surveys, and 207 hydrogeochemical surveys.

Program segment accomplishments through 1979 and plans for 1980 and 1981 are shown in Chart 12. The program plan for 1981 will complete the flying phase of the airborne radiometric reconnaissance survey; the results of which will be open filed in FY 1982. The status of the radiometric survey is shown in Charts 13 and 14.

The concept of a national hydrogeochemical survey will be dropped and future sampling done on field sites for which geochemical data are determined to be specifically needed. However, the national geochemical survey work completed through 1981 will have covered approximately one-half of the U.S. and will provide data for most of the higher priority areas. Charts 15 and 16 illustrate the status of the hydrogeochemical survey. It will be noted that a large part of the country has been sampled.

The quadrangle completion work for the various areas are shown in Charts 17 and 18. By the end of FY 1980, 116 top priority quadrangles will have been evaluated. In FY 1981, 30 additional quadrangle assessments will be completed. By the end of FY 1983, about 200 priority quadrangles will have been evaluated. The comprehensive assessment of the United States, covering the balance of the quadrangles, will be completed in the late 1980s.

While quantitative results from the systematic quadrangle assessments are limited, results so far suggest that the program will result in increases to our estimates of uranium resources. The more complete and comprehensive approach to development of basic field data and the detailed comparison of geology to known uranium deposits, of all types, tend to expand known favorable areas and also to identify entirely new favorable areas.

World Class Deposits

Besides the systematic quadrangle evaluation program, we are studying specific areas considered favorable for the occurrence of deposits similar to those found in other countries

(World Class deposits). In the U.S. most of the currently identified resources are in sandstone type deposits. These are located primarily in the Colorado Plateau area of Colorado, Utah, New Mexico, and Arizona; the sedimentary basins in Wyoming, and the Texas coastal plain. However, deposits in other countries have primarily been in non-sandstone geologic environments. Past exploration in the U.S. has not investigated similar geologic environments in any detail. In World Class deposit studies many areas and types of deposits will be investigated and promising sites will be studied in detail. Detailed studies, including drilling, on two specific sites will be completed by the end of FY 1980. Detailed study on four additional sites will be initiated in FY 1981.

Intermediate Grade Deposits

We are also investigating areas of known intermediate grade deposits, generally 0.01 to 0.05% U_3O_8, which have been below the grades of primary economic interest to the mining industry but which are relevant to nuclear power planning decisions. Most of such resources are expected to be producible at costs less than $100 per pound of U_3O_8.

Intermediate grade studies have identified over 50 candidate areas for studies. Detailed studies will be completed at three sites in FY 1980 and investigations begun at three other sites in FY 1981.

Subsurface Investigations

Subsurface investigations have involved drilling and logging to confirm estimates of resources, and to develop information on geologic conditions at depth for defining the nature and extent of favorable areas. Drilling also investigates World Class and intermediate grade sites.

Subsurface investigations, to be modified in FY 1981, will sharply reduce the amount of drilling. Logging of industry drilling, including non-uranium exploration holes, will be continued, but at lower levels.

INTERNATIONAL ACTIVITIES

To expand the quantities and geographic distribution of the identified world uranium resources, DOE participates in the International Uranium Resource Evaluation Project (IUREP) and cooperative uranium exploration R&D projects sponsored by the Nuclear Energy Agency and the International Atomic Energy Agency. IUREP has identified 40 priority countries where the possibility for discovery of uranium resources is good but where exploration and appraisals have been inadequate. Field investigations are underway and will continue in those priority countries into FY 1981. A number of cooperative research and development studies underway will improve the technology for identification and evaluation of uranium areas.

U.S. URANIUM POSITION

DOE's current estimates of U.S. uranium resources are shown in Chart 19. These estimates reflect input from the NURE Program; but, as previously noted, so far the NURE Program has reassessed only limited areas. The estimates are, therefore, an indication of our current knowledge and will change as work continues.

Ore reserves are contained in deposits delineated in detail, primarily by industry drilling. Those reserves producible at costs up to \$50 per pound of U_3O_8, are estimated at 920,000 short tons U_3O_8. At \$30 costs, which is closer to the level of economic interest at today's prices (in the low \$40s), reserves are 690,000 short tons U_3O_8. The DOE cost categories account for all costs required to find and produce the uranium at the time the estimate is made and, as such, they do not represent the prices at which the uranium might be available in the marketplace.

Resources not meeting the stringent requirements of detailed deposit drilling needed to establish reserves are defined as potential resources. DOE classifies potential resources into three categories: probable, possible, and speculative. The probable potential resources are those contained in extensions to known deposits and within delineated mineral trends, principally within the well-established uranium districts. Possible potential resources are contained in "productive" formations within "productive" uranium provinces, but outside the established mineral trends. "Productive" is arbitrarily defined as having resources or past production totaling 10 tons U_3O_8. Speculative potential resources are estimated for identified favorable areas within geologic formations or provinces that have not previously been "productive." Resource estimates presented here are unchanged from levels reported in 1979. Revised national estimates of uranium resources at \$30 and \$50 per pound of U_3O_8 and initial estimates of resources at \$50 to \$100 per pound of U_3O_8 will be available in October 1980, when a major report on the findings of the National uranium resource assessment will be issued.

Through the NURE Program, reserves and resources estimated at forward costs up to \$50 per pound of U_3O_8 are identified by their land status. Of the 920,000 short tons of reserves estimated as of January 1, 1979, 50.6 percent occur on lands in the public domain and 11.4 percent occur on Indian lands. Of the total estimated quantity of reserves and resources (4.1 million tons U_3O_8), 46 percent occur on lands in the public domain and 11 percent occur on Indian lands. Certain lands in the public domain have been and are currently under review for their wilderness potential. DOE has become actively involved in monitoring the progress of and making recommendations based on identified resource potential to the responsible Federal agencies regarding the management of their public lands. DOE was particularly successful in keeping certain tracts of relatively high uranium resource potential from being withdrawn during the Forest Service's RARE II study. The Bureau of Land Management is just getting underway in their effort to assess the wilderness potential of their public lands. It is possible that substantial areas containing estimated reserves may be dropped from their potential wilderness area inventory by virtue of the current extent of mining activities; nevertheless, DOE is working closely with BLM to assure consideration of uranium resource potential in their management plans.

In late 1979, the National Research Council's Committee on Nuclear and Alternative Energy Systems (CONAES) issued a report which addressed the role of nuclear energy in the United States. CONAES concluded that DOE's estimates of reserves and probable potential resources at forward costs up to $50 per pound of U_30_8 of "about 2.4 million tons" are reliable enough to plan on. CONAES also noted that if the additional resources estimated by DOE as possible and speculative were included, the estimate would rise to about 4 million tons. Thus, there is no basic disagreement between CONAES and DOE on uranium resources since CONAES, in effect, has accepted DOE estimates. In their report CONAES concluded that "a more complete assessment is needed of domestic and world uranium resources, and of the rate at which they can be produced at various costs." We agree with that conclusion.

While estimates of the magnitude, location, and economics of the resource base are important to understanding future availability, it is also necessary to evaluate the discoverability and producibility of these resources. A key factor is the quantity of uranium that can actually be produced annually in the future, which depends on the level of exporation and ore discovery rate, as well as the production expansion capability of industry. Detailed DOE studies of ore reserves and probable potential resource categories indicate that the capability for industry to expand production from the current annual rate of around 18,500 tons U_30_8 per year to a level in the early 1990's of around 60,000 tons from $30 resources does exist. This level could be further expanded by 15,000 tons if $30 to $50 resources were produced. An analysis of production capability from $30 to $50 resources done in late 1979 shows this level could be further expanded by 15,000 tons.

These attainable levels would provide the basis for expanded U.S. light water reactor capacity. The 60,000 tons of U_3O_8 could fuel some 300,000 megawatts of light water reactor capacity assuming 0.20% U-235 enrichment tails and no recycle of uranium or plutonium. Such production levels are attainable, but should be considered as upper limits which would require a diligent effort by industry in exploration, development of new mines, and construction of ore processing plants. Such activity of course depends on the future levels of demand for nuclear power plants as well as uranium prices.

INDUSTRY ACTIVITIES

The domestic uranium industry has been very vigorous in responding to growing uranium demands and increasing prices. Exploration, development, and production have increased in recent years. However, concern about the reduced projections of future uranium demand, softening uranium prices, lack of new procurement contracting and expanding low cost foreign resources, coupled with the increased regulatory difficulties for exploration and uranium milling have caused a cutback in industry activity.

In 1978 industry spent over $300 million for exploration, and drilled 48 million feet of holes; in 1979 industry drilled about 38 million feet or about 20 percent less that in 1978. This is 28 percent below the 53 million feet planned by the industry at the beginning of 1979. A similar pattern appears in mining and milling plant construction. The $427 million of capital funds expended in 1978 for new mines and mills were well below the $634 million that was planned for 1978 and below the $492 million spent in 1977. Planned expenditures for 1979 and 1980 were also reduced from a year earlier. While we expect the current level of industry activity will provide adequate uranium for the next several years, these observed reductions in exploration and production plant development may indicate a trend that could lead to future domestic supply difficulties and should be monitored closely.

Actual uranium production in the U. S. in 1979 was some 18,500 tons of U_3O_8 which was above actual 1979 requirements of around 16,000 tons U_3O_8. As shown in Chart 20, the uranium needed to fuel planned reactors is projected to grow to levels of around 25,000 tons in 1985, based on 114 GWe and 35,000 tons in 1990, based on 152 GWe of nuclear generating capacity. Total domestic supply consists of purchase commitments and additional material available for sale by domestic producers. This projected supply would be adequate to meet needs until the mid 1980s, but additional facilities must be constructed to cover the needs of later years.

Chart 20 also shows that projected uranium requirements for the mid-1980s and later are only partially covered by existing procurement contracts. Thus, utilities will have to buy substantial amounts of uranium to meet their future needs. The way in which utilities buy this additional uranium will influence U.S. producers' willingness to undertake additional development projects.

So far, foreign uranium has played only a minor role in meeting U.S. needs, because U.S. utilities have preferred to buy U.S. uranium. Given the size of the U.S. resource base and the fact that the producing industry is well developed, the U.S. should be able to meet its uranium needs in the future. However, U.S. producers might have to compete with generally lower-cost foreign producers for the U.S. market.

Uranium prices for new uranium contracts have been in the low $40 range for the last 3 years. Considering inflation, this has resulted in reduction of the real price. In addition, recently there has been reduction in nominal prices as well. This softening in prices reflects a more comfortable near-term supply-demand position, and increased optimism about adequacy of future supply. The reduction in uranium prices is causing some reassessment of exploration and production plans by producers, particularly those with higher cost resources. The important question is whether prices will stabilize at levels adequately reimbursing production costs and providing sufficient incentive for continued vigorous exploration. Or will prices drop too far, for too long--leading to future supply problems. We will continue to monitor this situation closely.

VI. PRESENT HEALTH OF PROGRAM

As concluding comments let me assess the health of the programs.

Overall program activities are proceeding smoothly and on schedule. While our production planning aims to balance supply and demand, we have adequate flexibility to respond to increased military and civilian needs. Within the short-term, production of low enriched uranium will slightly exceed demand. I do not believe this is cause for concern; it may enhance our reliability as a world supplier.

Recognizing that the demand for enrichment services is highly uncertain, we are increasing our efforts to monitor and evaluate the market environment, and to pursue the most cost-effective production mode possible. Gas centrifuge development continues to be highly successful and independent industry experts have endorsed it. I am confident that this technology will be fully demonstrated and ready for incorporation into the Gas Centrifuge Enrichment Plant at Portsmouth.

The gaseous diffusion complex continues to perform with greater than 99 percent on-stream reliability, and despite a prolonged strike at Portsmouth, production during the last year was within 96 percent of our target. Whereas the diffusion complex will continue to be the major portion of our enrichment capability, rising costs of electricity for the plants may require replacing some of this capacity with more energy efficient processes such as gas centrifuge or, in the longer term, advanced isotope separation methods. We are watching this situation closely, and will recommend appropriate action to the Congress when and if replacement is warranted.

I believe our contracting posture is now quite good. The terms and conditions under which we offer enrichment services are the most favorable in the world. This does not mean, however, that we can relax our efforts to market our services aggressively, or be responsive to customers' needs. We still need to do considerable work to restore and maintain our position as a reliable supplier of enrichment services. I believe we have come a long way towards this goal to date, and we are in a strong position to face the challenges ahead.

This concludes my statement, Mr. Chairman and Members of the Committee. I would be happy at this time to answer any questions.

CHART 1

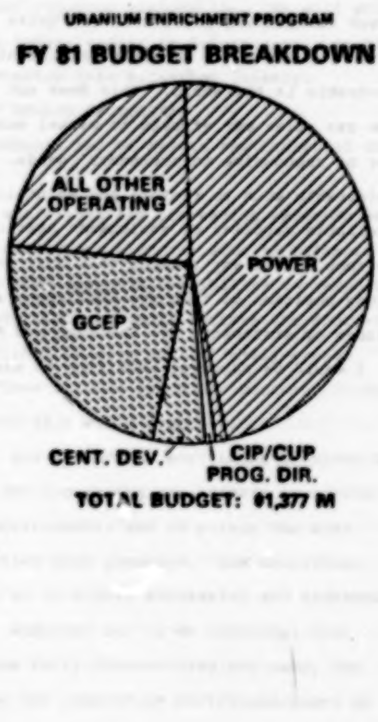
BUYERS OF DOE ENRICHMENT SERVICES

COUNTRY	NO. OF REACTORS	GWE	%	COUNTRY	NO. OF REACTORS	GWE	%
AUSTRIA	1	0.7	<1	S. AFRICA	2	1.8	<1
BELGIUM	3	1.7	↓	S. KOREA	8	5.9	2
BRAZIL	1	0.6	↓	SPAIN	9	6.9	2
EGYPT	1	0.6	↓	SWEDEN	11	8.4	3
FRANCE	3	2.2	↓	SWITZERLAND	6	4.0	1
INDIA	2	0.4	↓	TAIWAN	6	4.9	2
ITALY	3	1.4	↓	THAILAND	1	0.6	<1
JAPAN	58	49.9	16	UNITED STATES	206	199.8	66
MEXICO	2	1.3	<1	W. GERMANY	15	10.9	4
NETHERLANDS	2	1.1	↓	YUGOSLAVIA	1	0.6	<1
PHILIPPINES	1	0.6	↓	TOTALS	342	304.3	

CHART 2

URANIUM ENRICHMENT PROGRAM

FY 81 BUDGET BREAKDOWN

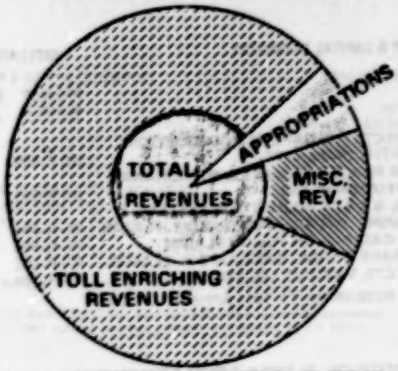


TOTAL BUDGET: $1,377 M

CHART 3

URANIUM ENRICHMENT PROGRAM

FY 81 REVENUE BREAKDOWN



TOTAL AVAILABLE FUNDS: $1,377 M

CHART 4

FY 1981 CONGRESSIONAL BUDGET REQUEST URANIUM ENRICHMENT ACTIVITIES

	BUDGET AUTHORITY (DOLLARS IN MILLIONS)	
	FY 1980	FY 1981
GASEOUS DIFFUSION OPERATIONS & SUPPORT		
CASCADE POWER	$548.3*	$647.0
DIFFUSION OPERATIONS	129.1	156.3
PROCESS & LONG-TERM TECHNICAL SUPPORT	14.5	14.5
SUPPORTING SERVICES	20.5	22.6
PLANT & CAPITAL EQUIPMENT	132.9	146.0
TOTAL GASEOUS DIFFUSION	$845.3	$986.4
GAS CENTRIFUGE OPERATIONS & SUPPORT		
GAS CENTRIFUGE PROCESS DEVELOPMENT & DEMONSTRATION	64.6	64.0
ALL OTHER OPERATING	1.0	.8
PLANT & CAPITAL EQUIPMENT	339.7	322.3
TOTAL GAS CENTRIFUGE	$405.3	$387.1
PROGRAM DIRECTION	2.4	3.0
REVENUES	-1,310.0**	-1,289.0
TOTAL	$-57.0	$ 87.5

*Excludes pending supplemental request of $54,600,000 for increased power costs.

**Excludes pending supplemental request decreasing revenue estimates by $253,000,000.

CHART 5

FY 1981 CONGRESSIONAL BUDGET REQUEST URANIUM ENRICHMENT ACTIVITIES

GASEOUS DIFFUSION - PLANT & CAPITAL EQUIPMENT

(DOLLARS IN THOUSANDS)

PLANT	PROJECT NUMBER	TOTAL ESTIMATED COST	FY 1981 OBLIGATIONS
ENVIRONMENTAL PROTECTION & SAFETY MODIFICATIONS, PHASE I GASEOUS DIFFUSION PLANTS	81-R-506	$ 55,000	$ 10,000
INSTRUMENTATION FOR PURGE CASCADES & WITHDRAWAL AREAS, GASEOUS DIFFUSION PLANTS	81-R-505	6,000	6,000
SUPERVISORY CONTROL & DATA ACQUISITION SYSTEMS, PADUCAH, KY. & PORTSMOUTH, OH. GASEOUS DIF. PLANTS	81-R-504	13,000	6,000
UTILITIES UPGRADING, GASEOUS DIFFUSION PLANTS	81-R-503	27,000	10,000
UF6 CYLINDERS & STORAGE YARDS, GASEOUS DIF. PLANTS	81-R-502	8,000	8,000
GENERAL PLANT PROJECTS, VARIOUS LOCATIONS	81-R-501	17,500	17,500
PRIOR YEAR PROJECTS REQUIRING FY 1981 APPROPRIATIONS			64,500
SUBTOTAL PLANT			$122,000
CAPITAL EQUIPMENT			24,000
TOTAL GASEOUS DIFFUSION -PLANT & CAPITAL EQUIPMENT			$146,000

CHART 6

PRIOR YEAR PROJECTS REQUIRING FY 1981 APPROPRIATIONS

GASEOUS DIFFUSION - PLANT & CAPITAL EQUIPMENT

(DOLLARS IN THOUSANDS)

	PROJECT NUMBER	TOTAL ESTIMATED COST	FY 1981
MOTOR & SWITCHGEAR UPGRADING, GASEOUS DIF. PLANTS	80-UE-5	$ 28,500	$12,000
POWER RECOVERY DEMONSTRATION CELLS, GASEOUS DIF. PLT.	80-UE-4	11,000	7,000
PLANT FACILITIES SECURITY IMPROVEMENTS, GASEOUS DIFFUSION PLANTS	80-UE-3	17,000	12,500
CONTROL OF WATER POLLUTION, GASEOUS DIF. PLANTS	80-UE-2	17,000	9,500
CONTROL OF GASEOUS EFFLUENTS, OAK RIDGE, TN. & PADUCAH, KY. GASEOUS DIFFUSION PLANTS	80-UE-1	7,000	3,500
PROCESS EQUIPMENT MODIFICATIONS, GASEOUS DIF. PLANTS	71-1-F	990,000	20,000
			$64,500

CHART 7

FY 1981 CONGRESSIONAL BUDGET REQUEST
URANIUM ENRICHMENT ACTIVITIES

GAS CENTRIFUGE - PLANT & CAPITAL EQUIPMENT	(DOLLARS IN THOUSANDS)		
	PROJECT NUMBER	TOTAL ESTIMATED COST	FY 1981 OBLIGATIONS
PLANT			
ENRICHED URANIUM PRODUCTION FACILITIES, PORTSMOUTH, OH. (GAS CENTRIFUGE ENRICHMENT PLANT)	76-8-g	$1,121,630*	$319,000
CAPITAL EQUIPMENT			3,300
TOTAL GAS CENTRIFUGE - PLANT & CAPITAL EQUIPMENT			$322,300

*Authorization requested to date. Total line item project cost is currently estimated at $5,500,000,000 in FY 1981 dollars, assuming project completion in FY 1993.

CHART 8

FY 1981 CONGRESSIONAL BUDGET REQUEST
URANIUM RESOURCE ASSESSMENT

	BUDGET AUTHORITY (DOLLARS IN MILLIONS)		
	FY 1980	FY 1981 REQUEST	CHANGE
OPERATING EXPENSES			
GEOLOGIC & RELATED INVESTIGATIONS	$ 47.7	$21.6	$-26.1
SURFACE GEOLOGIC & RELATED INVESTIGATIONS	19.9	12.2	-7.7
AERIAL SURVEYS	8.6	4.7	-3.9
HYDROGEOCHEMICAL SURVEYS	9.8	3.7	-6.1
SUBSURFACE GEOLOGIC INVESTIGATIONS	9.4	1.0	-8.4
TECHNOLOGY APPLICATIONS	3.9	3.8	- .1
SUPPORTING SERVICES	4.3	4.0	- .3
INTERNATIONAL ACTIVITIES	.5	.5	0
PROGRAM DIRECTION	4.3	4.6	+ .3
TOTAL OPERATING EXPENSES	$ 60.7	$34.5	$-26.2
CAPITAL EQUIPMENT	2.5	.5	-2.0
PLANT	1.5	.8	- .7
TOTAL URANIUM RESOURCE ASSESSMENT	$ 64.7	$35.8	$-28.9

CHART 9

CIVILIAN NUCLEAR POWER DEMAND

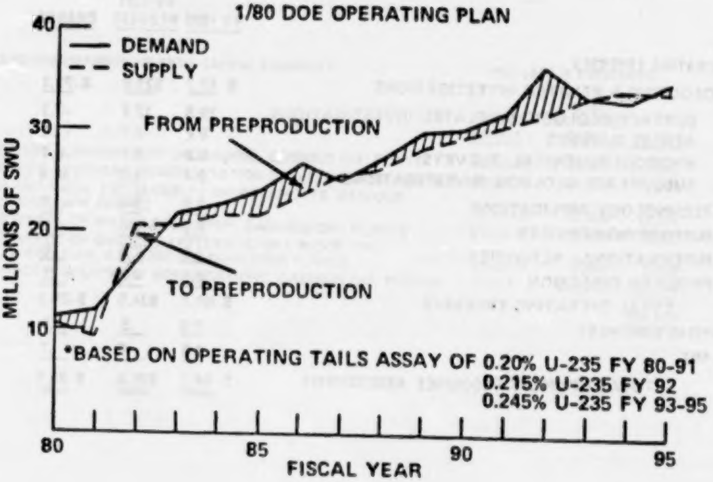
(1/80 DOE FORECAST)

END OF YEAR	GIGAWATTS ELECTRIC		
	U.S.	NON-U.S.*	TOTAL
80	56	35	91
85	107	54	161
90	147	80	227
95	179	115	294

*SUPPORTED BY DOE ENRICHMENT CAPACITY

CHART 10

ANNUAL SEPARATIVE WORK SUPPLY AND DEMAND*



*BASED ON OPERATING TAILS ASSAY OF 0.20% U-235 FY 80-91
0.215% U-235 FY 92
0.245% U-235 FY 93-95

CHART 11

SEPARATIVE WORK*CONTAINED IN THE DOE LOW ENRICHED URANIUM INVENTORY

(1/80 DOE OPERATING PLAN)

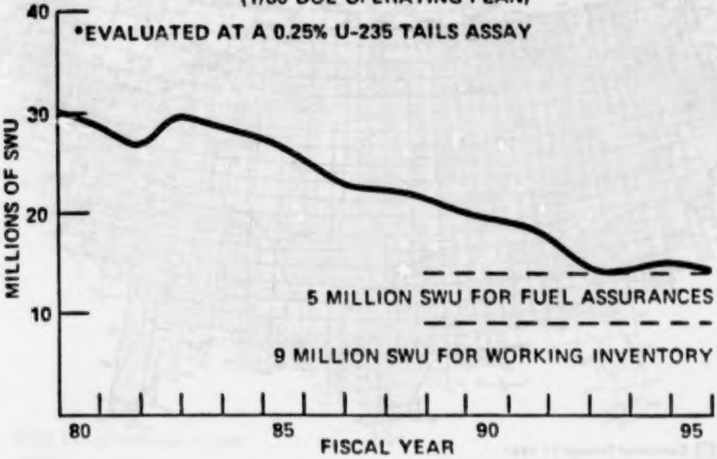


CHART 12

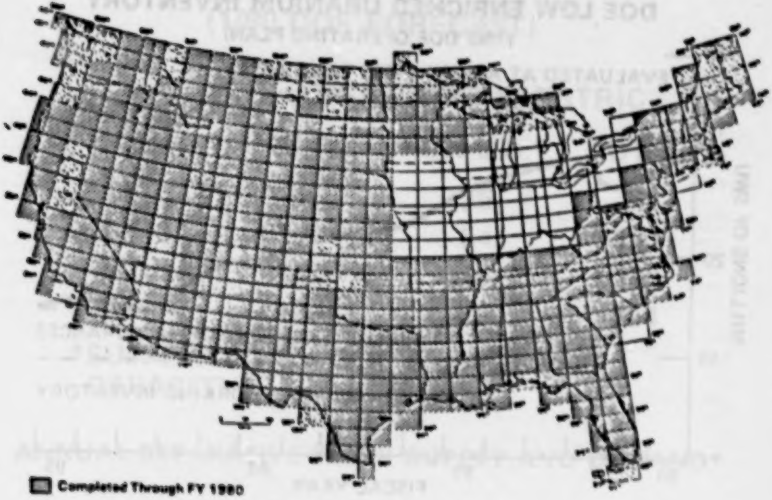
URANIUM RESOURCE ASSESSMENT MILESTONES QUADRANGLE ASSESSMENT PROGRAM

QUADRANGLE COMPLETIONS

ACTIVITIES	FY 1979	FY 1980	FY 1981
AERIAL SURVEYS	240 ▽	455 ▽	584 ▽
HYDRO SURVEYS	102 ▽	180 ▽	210 ▽
ASSESSMENTS	18 ▽	116 ▽	146 ▽
REPORTS	INURE ▽	116 ▽	

CHART 13

AERIAL RADIOMETRIC RECONNAISSANCE SURVEYS

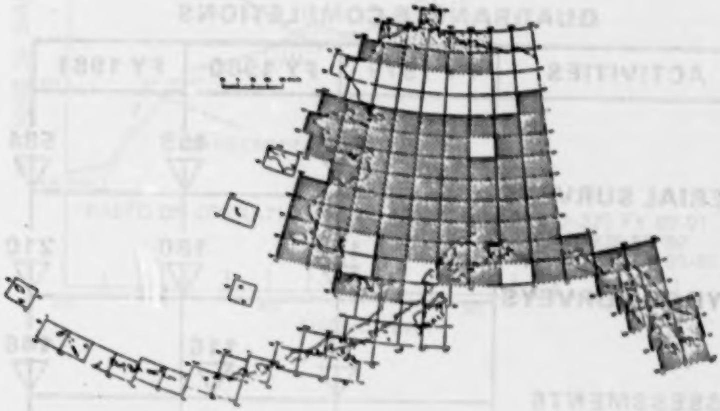


■ Completed Through FY 1980

▨ Flown But Not Completed Thru FY 1980

CHART 14

AERIAL RADIOMETRIC RECONNAISSANCE SURVEYS



■ Completed Through FY 1980

▨ Flown But Not Completed Through FY 1980

CHART 15

HYDROGEOCHEMICAL SURVEYS

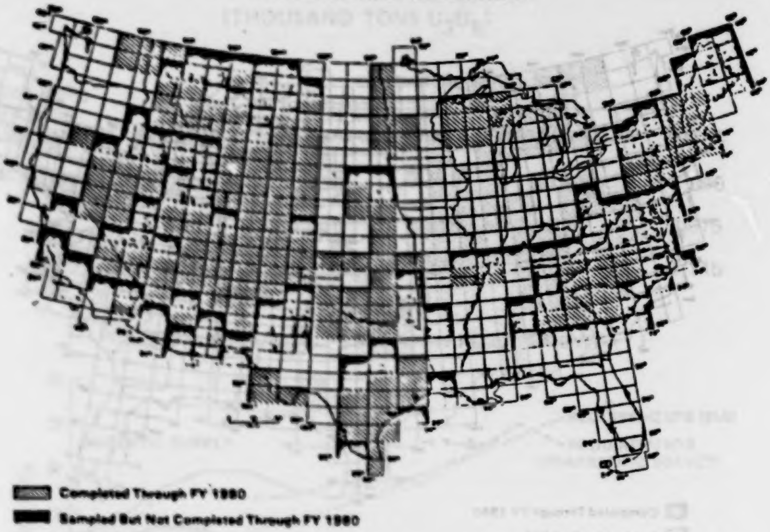

▨ Completed Through FY 1980
■ Sampled But Not Completed Through FY 1980

CHART 16

HYDROGEOCHEMICAL SURVEYS

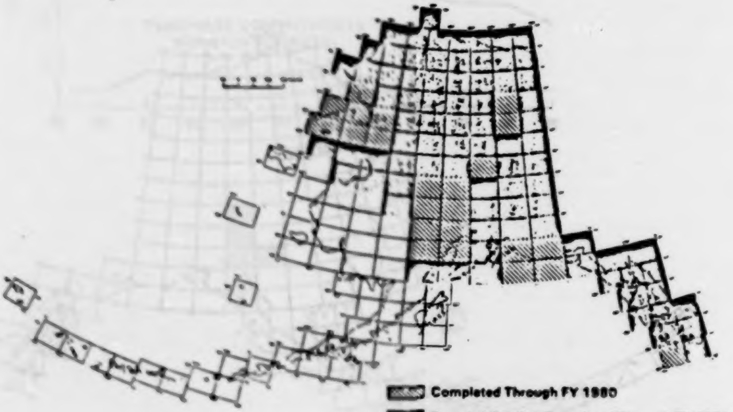

▨ Completed Through FY 1980
■ Sampled But Not Completed Through FY 1980

CHART 17
QUADRANGLE ASSESSMENTS

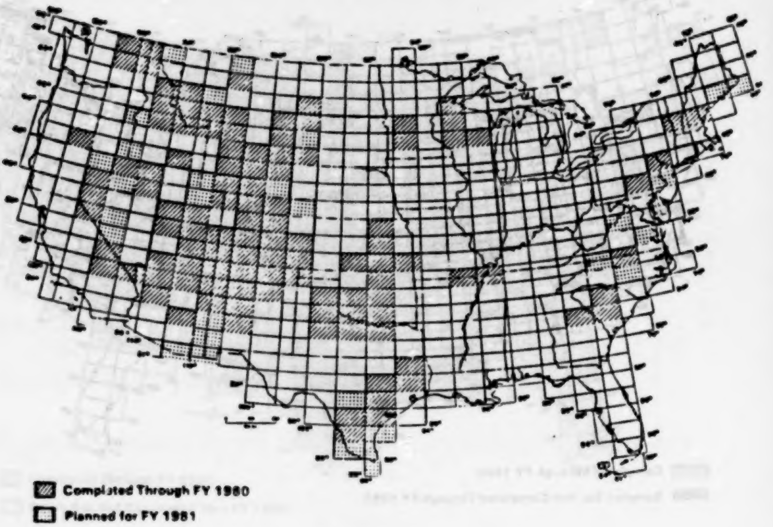

▨ Completed Through FY 1980
▦ Planned for FY 1981

CHART 18
QUADRANGLE ASSESSMENTS

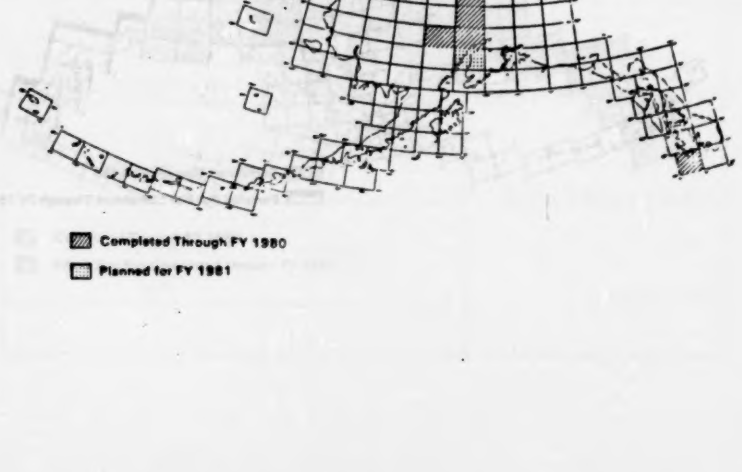

▨ Completed Through FY 1980
▦ Planned for FY 1981

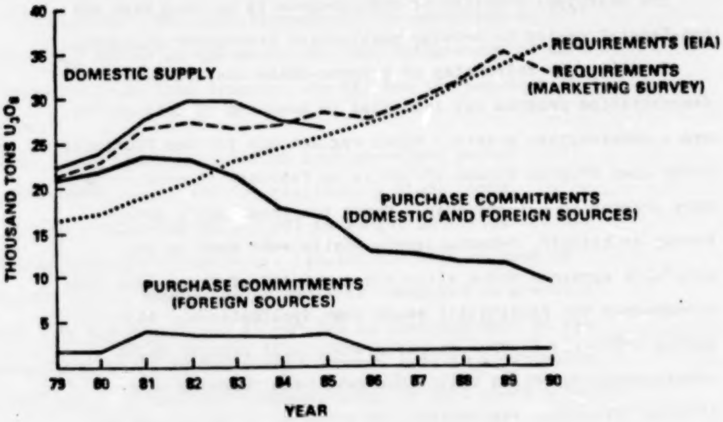
CHART 19

U.S. URANIUM RESOURCES
(THOUSAND TONS U_3O_8)

$/LB U_3O_8 COST CATEGORY	RESERVES	POTENTIAL RESOURCES			TOTAL
		PROBABLE	POSSIBLE	SPECULATIVE	
$15	290	420	210	80	1,000
$30	690	1,010	675	300	2,675
$50	920	1,505	1,170	550	4,145

CHART 20

DOMESTIC URANIUM SUPPLY vs REQUIREMENTS



In response to interest this committee has expressed in our small-scale hydro programs I would like to provide a brief overview of our plans in the next fiscal year and our accomplishments during 1980.

For FY 1981, the budget request for the Small-Scale Hydro Program is $19,000,000, a slight increase of $331,000 over the 1980 appropriation. Of this amount, $10,000,000 is requested for the Feasibility Study Loan Program. This budget request is, with one exception, generally level with FY 1980. The exception is commercial demonstration projects, for which we have requested a FY 1980 supplemental appropriation of $5,000,000, which would raise the current budget to $23,669,000.

The principal function of this program is to encourage the non-Federal sector to develop small-scale hydropower resources.

In 1980, the third step of a three-phase construction demonstration program was initiated in awarding 15 cost-shared hydro construction grants. Final regulations for the Feasibility Study Loan Program became effective on February 19 permitting this program to get underway. Under the President's Rural Energy Initiative, reconnaissance visits were made to 200 carefully screened hydro sites and about 140 of these have been recommended for feasibility study loan applications. Also during 1980, the Federal agencies which will provide hydro construction financing assistance have been changing their internal financial regulations and policies to better accomodate hydro construction financing needs. The final major base established in FY 1980 was the formation and development of a small-scale hydro outreach program in each of the ten Federal Regional Offices.

By the beginning of FY 1981, the hydro program will have achieved the experience in its outreach program to effectively support a broad range of activities in both the Feasibility

Study Loan Program and the REI. Regional meetings and site visits will be conducted to stimulate loan applications. Assistance will be available for completing loan applications. Regional resource studies initiated in FY 1980 should provide new information on existing dams which could be loan program candidates.

In FY 1981, the hydro REI should become an effective nation-wide program. As the financing agencies adjust their programs to assist hydro, our outreach offices will provide the coordination between the hydro developer and the appropriate field personnel of the financing agencies. As construction assistance cannot be finalized until a project is licensed, the Feasibility Study Loan Program is an integral part of the REI. The effectiveness of our principal FY 1981 thrust thus relies on the maturation and integration of our Feasibility Study Loan Program, the REI and the outreach program.

The hydro program is divied into principal parts: (1) Resource Development and (2) Feasibility Study Loans.

We are requesting $8,211,000 in budget authority for the resource development activity. $2,600,000 will be used to continue the 23 demonstration projects committed in previous years. We are requesting $1,900,000 to continue work in reducing impediments to hydro development; this is an increase of $800,000. In the environmental area, we will spend $800,000 to monitor a number of the demonstration sites for ecological changes that may result from hydropower development. We plan to spend $1,100,000 on the mitigation of institutional impediments. An important part of this effort will be directed at state permitting processes.

The FY 1981 request for $1,761,000 for engineering development is an increase of $1,260,000 over FY 1980. Most of this is for support of the engineering program at the Idaho National Engineering Laboratory and for the development of ultra low-head turbines.

Outreach activities, a vital part of our commercialization strategy, will receive $1,950,000. Funds will be distributed to 10 regional offices to support their work in identifying sites and supporting the Feasibility Study Loan Program and the Rural Energy Initiative.

The second principal part of the hydro program is feasibility study loans, for which we are requesting $10,000,000. This is the same level as in FY 1980. With the $10,000,000 requested in FY 1981, we expect to make approximately 150 feasibility study loans. We estimate that developers at half the sites studied will apply for loans for supporting the costs attendant to obtaining permits and licenses. This can be expected to lead to the development of approximately 225 megawatts of power-on-line.

In summary, we believe that the program is already playing a significant role in the reestablishment of the small-scale hydro industry, and that in FY 1981, the base which has been created for small-scale hydro will lead to an even stronger and more productive program.

Senator **Matsunaga**. Thank you, Dr. Davis. Now because of the time situation, if we have Mr. Sewell here, if you don't mind, we will have him testify and then ask our questions of both of them.

Senator **Domenici**. That's fine, Mr. Chairman.

Senator **Matsunaga**. Mr. Sewell will you then come forward and present your testimony?

Mr. **Sewell**. Mr. Chairman, with your permission I would like to submit a statement for the record and then briefly summarize it.

Senator **Matsunaga**. Without objection, your entire statement will appear in the record.

STATEMENT OF DUANE C. SEWELL, ASSISTANT SECRETARY, DEFENSE PROGRAMS, DEPARTMENT OF ENERGY, ACCOMPANIED BY RICHARD SCHRIEVER, DEPUTY DIRECTOR, OFFICE OF INERTIAL FUSION; AND EUGENE BECKETT, DEPARTMENT OF ENERGY

Mr. **Sewell**. Mr. Chairman and members of the committee, it is my pleasure to appear before you today to present highlights of our inertial confinement fusion and safeguards and security programs. I will introduce the other members with me at the time we get to questions.

In my testimony today I will give overviews for these two important programs and then respond to questions that you may have.

Inertial confinement fusion is an applied research program to produce energy from fuel, consisting of isotopes of hydrogen, using high power lasers or particle beam accelerators to heat and compress the fuel. Nearly three decades of work in the field of thermonuclear fusion both in national laboratories of the Department of Energy and its predecessor agencies, as well as in universities and industrial laboratories, has given us a good understanding of the conditions required for fusion and the technologies needed for practical application.

The considerable progress already made gives us increasing confidence that this research will provide important benefits both to our national defense and to our search for alternative energy resources for the future.

I would like to briefly describe that program, so that you will have a better understanding of it. The overall idea of the inertial fusion program is to concentrate the driver energy in time and space. This means that we are trying to take very high power and concentrate it for a very short time on a target such that it will heat and compress the thermonuclear fuel to the conditions necessary to produce thermonuclear energy.

There are two sources of driver energy. One of them is light from lasers, and the other is ion beams from accelerators. The actual coupling of the energy from these drivers to a target is a very important, but still not completely understood, physics problem.

The targets that I am referring to are very, very small. In fact, they are small micro balloons of glass filled with high temperature heavy isotopes of hydrogen. About 100 of these will fit on the head of a pin. That is how small they are. They are really microscope.

We take the energy from either the ion beams or the light beams, focus it appropriately onto these targets, and try to couple as much energy as we can into the target such that it does the following. It heats up the outside of the sphere to very, very high temperatures and literally explodes it. This outer explosion gives a rocket-like acceleration to the sphere in the reverse direction and compresses it to even smaller bits of matter; hopefully to the place where we get the conditions required for fusion release from the deuterium and tritium.

Now we have a question. We do not fully understand, as I said, the mechanisms of coupling this energy to the target. We do have some theories that for light beams, the shorter the wavelength, the better; for ion beams, the heavier the ions, the better. In fact, we are now looking at quite a variety of long wavelength, relatively long wavelength, and short wavelength laser light beams.

We are also looking at light ions as well as heavy ions. The present experimental program in the laser area consists of two independent efforts, one at the Los Alamos National Scientific Laboratory, and the other at the Lawrence Livermore National Laboratory.

Los Alamos is looking at the longer wavelength Helios and Antares systems using carbon dioxide laser drivers. Lawrence Livermore, with the help of the University of Rochester, KMS, and the

Naval Research Laboratory, is looking at shorter wavelength lasers that are actually glass that produce the laser light.

In the area of particle beam drivers, the Sandia Laboratory is looking at light ions. From this program we expect to get an understanding about those questions that I mentioned earlier.

Theory tells us that the Shorter wavelengths and the heavier ions will be the better place to look for the final solution to this problem. Therefore, $30 million in our budget proposed for fiscal year 1981 is devoted to those two areas: Shorter wavelength lasers and heavier ions.

One question that comes out of this program is why is it in the weapons area? There are two reasons for that. First, many targets are a little more complicated than I described earlier, and do use classified weapons information and know how to design these.

Second, the first use of inertial confinement fusion will be in the weapons program, since the weapons program does not require high average power or very rapid pulsing. Only one pulse every hour or two is adequate for that program. Since that is the way we are doing experimental programs to date, that naturally leads to the first application in the weapons area.

During the last year we have accomplished a large degree of program integration, and at the same time decentralized the technical management of the program elements to the field. This approach will focus our scientific energies on solving the technical problems which must be overcome in developing the full potential of ICF technology.

Within our resources, we must effectively address the key technical issues now so as to be able to make intelligent choices concerning the best approaches for the high power reactor systems later in the decade.

This concludes my statement on inertial confinement fusion. With your permission, I will go ahead with the Safeguards and Security testimony.

Senator **Domenici**. Might I ask what is the funding level for inertial confinement this year, 1981 versus 1980?

Mr. **Sewell**. Our fiscal year 1981 funding request is $202 million. $159.5 of that is for operating expenses. In fiscal year 1980 our total budget is $94.9 million including the $3 million that we have asked for in the supplemental budget. $114.9 million of that is for operating expenses, and that also includes the $3 million in the supplemental request.

Senator **Domenici**. The negative on construction, I assume you did not need this much construction in 1981, is that correct?

Mr. **Sewell**. Yes, that is due to the fact that we are requesting no funds for the NOVA facility in fiscal year 1981.

Senator **Domenici**. Thank you, Mr. Chairman.

Mr. **Sewell**. Shall I proceed with my safeguards and security testimony now?

Senator **Matsunaga**. Yes.

Mr. **Sewell**. The primary responsibility of the Office of Safeguards and Security is to work with responsible DOE program managers to assure that adequate protection is provided for DOE nuclear weapons facilities, materials, and classified information against threat of theft and sabotage by potential adversaries.

In carrying out this responsibility, we set policy, manage a research and development program, coordinate with responsible DOE program officials, and provide oversight on effective implementation.

A large part of our research and development program is aimed at developing and evaluating safeguards and security instruments, components, subsystems and procedures to provide a base of technology which can be used by the field and program managers in providing adequate protection for both existing and new facilities.

Another major part of this research and development program is oriented toward assisting the DOE contractors in putting together new safeguards and security systems or adapting existing ones that integrate physical protection, material control and material accountability.

Finally, we have an oversight responsibility which includes the review of the implementation of safeguards and security at DOE facilities to assure that the policies and standards are being adhered to and that the systems in place are indeed adequate and effective in countering perceived threats.

While our major responsibility must be to support DOE managers in assuring adequate protection of nuclear weapons facilities and materials, this same technology base, with some modifications, supports a number of other important activities as well. The same components and systems are directed toward helping assure that nonnuclear resources of DOE, particularly those important to national security and the public well being, receive effective protection against potential adversaries.

Additionally, we make available to the private nuclear industry and the Nuclear Regulatory Commission, safeguards and security information which can enable them to provide and asssure adequate protection of nuclear materials and facilities in the private sector.

It should be noted that we cooperate closely with the NRC to maintain comparably effective protection at DOE and licensed facilities.

The program also focuses on providing safeguards and technical support to U.S. and international activities designed to minimize the possible proliferation of nuclear weapons. In particular, this involves participation in U.S. efforts to identify and promote promising nuclear fuel cycles, support the International Atomic Energy Agency, IAEA, in its safeguard objectives to effectively inspect peaceful nuclear activities, and cooperate with other nuclear nations in protecting their materials and facilities, particularly materials supplied by the United States. In addition, we conduct a limited data exchange program on international nuclear materials transactions.

It is quite important in understanding the safeguards and security program to recognize that it is a dynamic discipline. Adversaries change with time as do their capabilities and intentions. Targets become more numerous, more varied, and more or less attractive for adversary actions; and our capabilities for protecting such facilities continue to increase.

Threats vary with location and changes in the sociopolitical climate. Also, public tolerance of risk is modified with experience.

In summary, Mr. Chairman, we believe that safeguards and security equipment and systems have been improved in recent years and will continue to improve in effectiveness in coming years.

This, Mr. Chairman, concludes my statement, and I will be happy to respond to questions.

[The prepared statement of Mr. Sewell follows:]

STATEMENT OF DUANE C. SEWELL
BEFORE THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
MARCH 24, 1980

Mr. Chairman and Members of the Committee, it is my pleasure to appear before you today to present highlights of our Inertial Confinement Fusion and Safeguards and Security programs. With me today are Dr. Philip Coyle, Deputy Assistant Secretary for Defense Programs, Dr. Richard Schriever, Deputy Director of the Office of Inertial Fusion and Mr. George Weisz, Director, Office of Safeguards and Security.

In my testimony today, I will give program overviews for these two important programs and then respond to any questions you may have.

Inertial Confinement Fusion

Inertial confinement fusion is an applied research program to produce energy from fuel consisting of the isotopes of hydrogen, using high power lasers or particle beam accelerators to heat and compress the fuel. Nearly three decades of work in the field of thermonuclear fusion, both in the national laboratories of the Department of Energy and its predecessor agencies, as well as in universities and industrial laboratories, has given us a good understanding of the conditions required for fusion and the technologies needed for practical application. The considerable progress already made gives us increasing confidence that this research will provide important benefits both to our national defense and to our search for alternative energy resources for the future.

In 1978 and 1979, with the Shiva and Helios laser systems both in routine operation, we learned a great deal about the complex physics involved in coupling energy into a fuel pellet. Within the past year, fuel compressions of roughly 100 times liquid density have been achieved with Shiva and 20 times liquid density with Helios. These results are comparable to some of the best results in the magnetic fusion program and are key steps to achieving a full demonstration of the scientific feasibility of large energy gains from inertial fusion. However, this demonstration will require energy sources many times larger than those now in operation. Thus, our current program efforts are focused on exploring pellet fusion physics while simultaneously developing the technologies of laser or particle beam drivers, the diagnostics for the unique conditions of pellet fusion, and the fabrication of complex fuel pellets for larger fusion yields.

The core program in inertial fusion physics is located in the national laboratories to capitalize on fusion design capabilities and related resources, including materials science, which inertial fusion shares with our nuclear weapons physics programs. With new results from our ICF research and when larger fusion energy yields from pellets become available, we will be able to apply those results back to weapons technology and weapons physics research in support of our national security.

However, the ultimate challenge of ICF research is the development of power systems for civilian energy production. Here, large energy gains and reliable, efficient repetitive operation of fusion driver systems depend on highly developed driver and pellet technologies, as well as new systems for pellet injection and tracking, containment, and transfer of the energy released, tritium fuel cycling, and acceptable safety and environmental features.

Role of National Laboratories

In its conference report on our FY 1980 budget for inertial fusion, the Congress endorsed the lead-laboratory approach as a device to more effectively manage research and development funds in the inertial fusion program. As in the nuclear weapons program or the magnetic fusion program, we will be using the technical and managerial expertise of the National Laboratories (particularly the Lawrence Livermore, Los Alamos, and Sandia Laboratories) to coordinate scientific work and ensure that undesirable duplication of effort will be avoided. As in the recent past, universities and industry will continue to play a major role in the ICF program. In FY 1979, roughly 50% of all ICF program operating and equipment funds went to universities and private industry and 80% of all construction funds utilized the capability of industry. We plan for univesities and industry to hold a similar share of our programs in FY 1980 and FY 1981. I have instituted the lead-laboratory approach as being appropriate to a program that has resolved enough of the scientific uncertainties to be able to define how to go about the task of demonstrating feasibility. The demonstration itself may not occur until the late 1980's. In addition to accomplishing this demonstration, we will establish in the nuclear weapons laboratories a capability to accomplish the military applications of inertial fusion technology and broaden the contributions of universities and industry to the later realization of the civilian applications. The applied research activities in inertial fusion also make a significant contribution to attracting scientists that are trained in disciplines important to both the nuclear weapons design laboratories and to the future of strong fusion research programs in this country.

The major program elements in our inertial fusion effort are the development of inertial fusion theory through glass laser and carbon dioxide laser experiments, laser and particle beam machine development, advanced driver development, and target fabrication technology. As I said earlier, we have grouped most of these activities under lead-laboratories to avoid undesirable duplication of effort and to focus program efforts on obtaining meaningful and relevant results.

CO_2 Laser Experiments

The CO_2 laser experiments program is the responsibility of Los Alamos, which has developed the largest CO_2 lasers in the world designed for fusion experiments, and the only ones of their kind in the United States. The latest of these, the Antares high energy gas laser, is now under construction. The CO_2 laser is well known for its characteristics of efficiency, scalability, and repetitive operation that are required for fusion power reactor systems. The major uncertainty of this approach is in long wavelength target coupling physics. We will not be able to evaluate fully this promising laser until we can irradiate targets with substantially more energy than is available from the Helios system now in operation at Los Alamos. For this purpose, we are developing the Antares laser system, which is the only long wavelength laser planned to be developed for high energy and power. The near-term objective of this program element is to determine whether or not the carbon dioxide laser is capable of development as an efficient target irradiation system for both single-pulse and civilian power reactor operation. At Sandia, there is a small effort on the hydrogen fluoride gas laser, which is potentially quite efficient and capable of repetitive operation at a wavelength intermediate between neodymium glass and carbon dioxide.

Glass Laser Experiments

The glass laser experiments program is centered at Livermore but includes important work conducted at the Naval Research Laboratory, KMS Fusion, Inc., and the University of Rochester. These are the principal locations for neodymium glass laser experiments, both at the one micron wavelength which is normal for such lasers and at still shorter, visible wavelengths such as half micron (green) or third micron (blue). Lasers of these shorter wavelengths potentially offer better target coupling. Experiments to confirm this are underway, but the development of efficient short wavelength systems still needs to be demonstrated. Livermore's Argus and the KMS system are already being used to simulate the target irradiation characteristics of advanced short wavelength lasers that are yet to be developed.

Our ability to study the complex interactions occuring in the targets has grown in recent years with the development of a series of laser systems leading to the Nova high energy glass laser now under construction at Livermore. As now planned, the Nova system will be capable of operating in the blue and green portions of the spectrum, as well as at [illegible] micron, providing broad experimental flexibility at high power and energy. The University of Rochester has developed a flexible target irradiation system which can add significantly to our glass laser experimental data base. We have supported this development at Rochester which will be completed later this year, as well as upgrades of the smaller lasers at NRL and KMSF. This program element also requires ongoing development of target fabrication technology and diagnostic instrumentation. The near-term objective of the glass laser program is to demonstrate laser-target coupling at various wavelengths and at high power and to gain a thorough understanding of the requirements for reactor class laser and pellet designs which can reach large fusion energy yields. These will also have immediate applications in weapons technology development while laying the groundwork for full development of civilian energy technology.

Pulsed Power Experiments

The program effort in electron and light ion beam drivers for fusion experiments is centered at the Sandia Laboratories, Albuquerque, and includes a small but critical effort at the Naval Research Laboratory. The technology of light ion beam generation using the pulse power machines developed at Sandia for simulating some weapons effects has progressed rapidly, making this a significant backup approach to laser-induced fusion. Compared to the more widely known laser approach, the light ion approach appears to be lower cost but higher risk. Later this year, we will reach an important milestone in this effort when we begin operation of the first phase of the Particle Beam Fusion Accelerator at Sandia. In FY 1981, we will begin the second phase of this project, which will reach the energy and power levels that are of interest for both the military applications and for experiments to test the scientific feasibility of the basic inertial fusion concept.

Advanced Drivers

The development of advanced drivers, both short wavelength gas lasers and heavy ion accelerators, has reached the point where we are ready to test scaling features. These are candidate drivers which promise to have good electrical efficiencies, as well as the coupling characteristics required to drive pellets efficiently to ignition conditions. Target performance for very short wavelength lasers will be simulated using frequency-multiplied glass laser systems. Although some idea of heavy ion target performance can be gained from light ion experiments, the issues of accelerator design and cost, beam transport and focusing in larger scale systems will be explored in increasingly more powerful heavy ion prototypes. The next step will be to build testbeds to demonstrate that candidate heavy ion and advanced laser approaches are capable of being scaled to the energy and power requirements for full fusion applications. To facilitate this development, we have assigned lead-laboratory responsibilities for heavy ions to Los Alamos and for advanced lasers to Livermore. Each of these laboratories will coordinate the work of other participants, including other national and Government laboratories, industry, and universities. Most of the heavy ion development funds will go the the Argonne and Lawrence Berkeley National Laboratories, while the great majority of advanced laser funds will go to industry.

Target Fabrication

For the experimental programs, we need to continue development of the target fabrication technology which is as critical to eventual success as is the driver development. We are constructing target development laboratories at Livermore and Los Alamos in which researchers will fabricate targets for ongoing experiments and develop the techniques for target manufacture that will be required for the downstream applications, both military and civilian. KMS Fusion has also demonstrated significant target fabrication capabilities and we are planning to maximize the KMS role in this area.

This completes my brief survey of the various elements of the current program and the near-term development of facilities. Looking back a decade, we have seen rapid and generally successful development of key technologies. We have demonstrated fusion yields with both laser and particle beam drivers, confirmed the thermonuclear origin of the neutron emissions, and made a beginning in the more difficult stage of reaching the significant target compressions required for fusion ignition conditions.

We see no scientific or technological problems that would prevent demonstration of feasibility with the drivers we are now developing. But as the primary tools, the laser and particle beam drivers, become increasingly large and complex, it is clear that we cannot continue to provide every program with its own driver facilities for research.

During the past year, we have accomplished a large degree of program integration, and at the same time decentralized the technical management of the program elements to the field. This approach will focus our scientific energies on solving the technical problems which must be overcome in developing the full potential of ICF technology. Within limited resources, we must effectively address the key technical issues now so as to be able to make intelligent choices concerning the best approaches for high power reactor systems later in the decade.

This concludes my overview of the Inertial Confinement Fusion program. I would now like to turn to our Safeguards and Security program.

Safeguards and Security

The primary responsibility of the Office of Safeguards and Security is to work with responsible DOE program managers to assure that adequate protection is provided to DOE nuclear weapons, facilities, materials, and classified information against theft and sabotage by potential adversaries. In carrying out this responsibility, we set policy, manage a program of research and development, coordinate with responsible DOE program officials, and provide oversight on effective implementation.

We support DOE program managers and field managers who are responsible for the facilities and operations in a number of ways. We provide DOE-wide policies, standards, and guidance on what threats these facilities and operations have to be prepared to successfully counter, and what requirements must be met by their safeguards and security systems to be effective.

We manage a research and development program. A large part of this program is aimed at developing and evaluating safeguards and security instruments, components, subsystems, and procedures to provide a base of technology which can be used by the field and program managers in providing adequate protection for both existing and new facilities. Another major part of this research and development program is oriented toward assisting the DOE contractors in putting together new safeguards and security systems or adapting existing ones that integrate physical protection, material control, and material accountability. Such systems must be relevant to field needs and effective against the perceived range of credible threats. Actual implementation and operation of the safeguards and security systems for protecting weapons, nuclear materials, facilities and classified information are funded by the responsible program managers. We coordinate with the program managers and support field implementation of these systems. We are also taking steps to minimize the potential consequences of malevolent threats or acts through contingency planning and the use of special emergency response resources.

Finally, we have an oversight responsibility which includes the review of the implementation of safeguards and security at DOE facilities to assure that the policies and standards are being adhered to and that the systems in place are indeed adequate and effective in countering perceived threats.

While our major responsibility must be to support DOE managers in assuring adequate protection of nuclear weapons, facilities and materials, this same technology base, with some modifications, supports a number of other important activities as well.

These same components and systems are directed toward helping assure that non-nuclear resources of DOE, particularly those important to national security and the public well-being, receive effective protection against potential adversaries. Additionally, we make available to the private nuclear industry and the Nuclear Regulatory Commission (NRC), safeguards and security information which can enable them to provide and assure adequate protection of nuclear materials and facilities in the private sector. It should be noted that we cooperate closely with the NRC to maintain comparably effective protection at DOE and licensed facilities. The program also focuses on providing safeguards technical support to U.S. and international activities designed to minimize the possible proliferation of nuclear weapons. In particular, this involves participation in U.S. efforts to identify and promote promising nuclear fuel cycles; support the International Atomic Energy Agency (IAEA) in its safeguards objectives to effectively inspect peaceful nuclear activities; and cooperate with other nuclear nations in protecting their materials and facilities, particularly those supplied by the U.S.; and conducting a limited data exchange program on international nuclear materials transactions.

It is quite important in understanding the safeguards and security program to recognize that it is a dynamic discipline. Adversaries change with time as do their capabilities and intentions; targets become more numerous, more varied, and more or less attractive for adversary actions; and our capabilities for protecting such facilities continue to increase. Threats vary with location and changes in the socio-political climate, and public tolerance of risk is modified with experience. As a result, what was adequate in the past may be more than adequate or insufficient in the future. Therefore, the process of providing safeguards protection and assuring the adequacy of the protection is a continuing one. As part of this, our perceptions of the threat have changed from time to time, and no doubt will continue to be modified as a reflection of future events. Likewise, safeguards system requirements must also continue to change with time. I will now turn to the specific program activities.

Operating Programs

There are two major program areas: a research and development program and an operational support program.

Research and Development

The objective of the research and development program is to provide safeguards and security methods, components and systems which, when implemented, are effective against a range of potential credible threats.

Threat and Risk Characterization

Fundamental to the entire program is an understanding of the range of possible adversaries and targets and the consequences of potential hostile acts. In FY 1980 we are broadening our threat and risk evaluations in several dimensions. First, we are initiating studies with the objective of improving our understanding of the potential problems from people inside our systems, including strategies to deter or defeat such adversaries. To improving our ability to identify important risks and vulnerabilities, including the social and political dimensions of the threat and use of plutonium as a radiological weapon. A limited number of such non-technical studies are or will be competitively contracted and represent a conscious intent to broaden participation in this multi-disciplined program.

A comprehensive evaluation of risk and consequences of possible malevolent acts against DOE facilities will be completed in FY 1981. This effort should provide the basis for identifying major vulnerabilities that will require additional policy changes, R&D, security enhancements, and further studies. The risk and consequence assessments will be coupled with our continuing evaluation of the characteristics and attributes of adversaries to produce more refined guidance with regard to the major threats these facilities face.

A key policy product which will be developed in part with support from these studies will be the issuance of a revised threat guidance. The guidance will provide important benchmarks against which the effectiveness of the safeguards in place at DOE's nuclear facilities can be measured. Its adaption to apply to DOE nonnuclear facilities, such as the Strategic Petroleum Reserve Office will be addressed. Additionally, in FY 1981, a mechanism to periodically review and issue this threat guidance will be implemented. This will add an ability to identify short term changes in threat that can be responded to by operational changes.

Safeguards Evaluation and Methodology

Safeguards evaluation and methodology is the first step in the safeguards research and development process to develop countermeasures to nullify the threat. It involves application of methods to systematically highlight design requirements of safeguards systems, highlight deficiencies of existing systems, and assist us in evaluation of the effectiveness of these systems. The FY 1981 effort will be directed at making greater use of computer simulation models and data processing equipment to improve the design and evaluation of safeguards systems.

Technology Development

Vulnerabilities and potential countermeasures identified in the concepts are used as a basis for "Technology Development" to adapt or design, develop and evaluate prototype instrumentation and components under controlled conditions as well as in an operational environment. In FY 1981, there will be continued emphasis on the development of advanced non-destructive assay (NDA) instrumentation and better measurement standards to solve problems in measuring special nuclear material (SNM, which is plutonium and enriched uranium)* in a more rapid, accurate way and with reduced direct access or exposure to operating personnel. The instrumentation is being designed to go on-line on normal process streams, where possible, and will be used for scrap and waste processing and spent fuel storage. The objective is to provide information on the location and condition of SNM in a more timely and accurate manner to minimize inventory differences and detect attempted diversions. Additionally, we will continue to develop improved components and systems to provide means for more positive control of personnel entering into or leaving a facility or having access to SNM. This will include better intrusion detection equipment which is more sensitive and less susceptible to false alarms, and more reliable and sensitive devices to detect metal, explosives, and SNM. A prototype of automated equipment for positive personnel identification and control will be tested and evaluated by the end of FY 1981.

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*Isotopes U-233 and U-235

By FY 1981, exterior and interior intrusion sensors and closed circuit TV cameras will be available as state-of-the-art technology for use by field managers. We will also complete major development and evaluation of active and passive barrier technologies. Other physical protection activities will include work on improved guard communication equipment, and sensor systems test and evaluation.

FY 1981 work will include an extension of these efforts. Potential improvements in microwave and other exterior sensors, more effective ways of applying video motion detection techniques, and the combination of intrusion detection sensors will also be investigated.

Systems Design and Implementation

Systems design and implementation activities will build directly on FY 1980 activities for developing integrated safeguards systems. System design activities include the development of a national spent fuel storage system design and associated equipment development, and system concepts for major nuclear facilities such as the liquid metal cooled fast breeder reactor (LMFBR). In addition, we are developing a systematic approach to assist program managers in protecting non-nuclear DOE facilities of national security significance against malevolent acts.

The system implementation effort provides direct safeguards and security expert assistance to field offices and DOE contractors to help them assure that DOE's facilities have adequate safeguards and security systems. The system implementation in both FY 1980 and 1981 will support safeguards at specific major DOE installations* as well as provide more generic support through guard armed engagement education. Other implementation support tasks will focus on establishing new systems and procedures, and identifying sources of malfunctions in existing equipment.

Operational Support Program

Incident Management

Management capability for dealing with safeguards and security incidents will continue in FY 1981.

The Incident Management activity is required to manage incidents resulting from

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*They include:
- LASL, TA-55
- Oak Ridge, Y-12
- Savannah River, Production Reactors
- Idaho Falls, Zero Power Plutonium Reactor (ZPPR)

malevolent acts or threats directed against DOE facilities or operations or threats involving improvised nuclear explosive or dispersal devices. In FY 1981, the activity will continue its direct support of the Nuclear Emergency Search Team (NEST) in terms of enhancing NEST capabilities for search and diagnostics involving improvised nuclear devices. In addition, we have established a capability for rapidly determining the credibility of communicated threat messages. This capability has greatly facilitated our ability to respond appropriately to the many threats which are directed at DOE interests. Finally, in order to assure an effective organizational response to an emergency, we have conducted two major exercises which involved the major emergency response elements of the Department as well as the FBI.

The expansion of the Incident Management function in FY 1981 will enable us to establish and maintain a terrorist data base for utilization during an incident. Also, we will define our system requirements for response to emergencies at major nonnuclear DOE facilities.

Assessments

An assessments program to conduct independent reviews of the effectiveness of DOE systems for protection of DOE's national security level interests is supported under the operational support programs. This activity, which is under the direct supervision of the Assistant Secretary for Defense Programs, consists of reviews of the quality of management interaction and the effectiveness of DOE protective systems. In FY 1980, reviews will be conducted of three field offices including certain facilities under their administration;

for FY 1981, this program is planning to conduct reviews at approximately six field offices as well as conduct special studies as requested by the Assistant Secretary .

Safeguards Analytical Laboratory

The Safeguards Analytical Laboratory provides nuclear materials measurement support to the defense programs and monitors DOE contractors' measurement performance, and develops analytical standards and measurement procedures. This laboratory provides similar services to the NRC and the IAEA on a full cost recovery basis.

Nuclear Materials Management and Safeguards Systems (NMMSS)

The NMMSS is a computerized nuclear materials information and safeguards data system that provides the central repository for storage and retrieval of information on 19 nuclear materials vital to DOE production and defense programs, including those under safeguards control. Input to the NMMSS is provided by all DOE contractors and private firms licensed by the NRC. U.S. nuclear materials furnished under international agreements to foreign countries are also tracked by this system. In FY 1981, NMMSS will be modified to enable the U.S. to meet its formal reporting requirements to the IAEA under the terms of the U.S. offer to place selected non-defense nuclear facilities under IAEA safeguards. These requirements will become effective following Senate ratification of the U.S.-IAEA safeguards agreement.

International Activities

The final "International Activities" effort involves the transfer of safeguards technology to the International Atomic Energy Agency and the international community. This effort, which is closely coordinated with the Department of State, the Arms Control and Disarmament Agency, and the Nuclear Regulatory Commission, provides for rapid transfer of newly developed safeguards technology and information as appropriate to the IAEA and to other countries to enhance international safeguards. In FY 1981 we will continue to conduct international training and transfer safeguards technology to the international community. Basic training courses will expand to include more comprehensive training in physical protection and nuclear material control and accountability. This task is complementary to the Program for Technical Assistance to IAEA Safeguards (POTAS), which provides U.S. support for the transfer of DOE-developed technology to the IAEA.

This completes my description of the operating programs assigned to the Office of Safeguards and Security.

New Initiatives

As I mentioned before, the nature of our protection program requires that we maintain the flexibility to react rapidly to changing safeguards and security needs. Thus, before concluding, I would like to highlight briefly some of the new initiatives we are undertaking through our office. First, we have taken positive steps to broaden the base of our technical and other programmatic activities. This will provide new insight and perspectives and furnish a degree of independent peer review which will benefit the entire program.

In addition, it will allow us to integrate the human elements of safeguards into our program in a positive way. The Three Mile Island accident has borne witness to the fact that it is difficult to predict the responses of both personnel and equipment to changes in complex systems. Safeguards and security differ from safety, however, in that human motivations, capabilities, and responses play key roles in both causing and responding to safeguards incidents and, therefore, are even more fundamental to understanding and enhancing our effectiveness. In recognition of this fact, we are devoting increasing attention to the human component of safeguards and security systems. Activities in this area will include an improved security awareness program, the study of how safeguards and security systems may best be emplaced to complement the capabilities and responses of the individuals who must operate them, and the study of the deterrence features of those systems.

In discussing our threat characterization program it was noted that the most certain thing about the future is that it is uncertain. In light of this, we are taking steps to involve those most affected in the DOE field to participate in the development and dissemination of comprehensive and timely threat guidance. A major focus in FY 1981 will involve an in-depth evaluation of internal conspiracy as part of threat characterization.

Partly in response to this hypothetical insider threat and to minimize the chances that such a threat might become a reality, we are also taking some internal security initiatives for day-to-day operations within the Department. These initiatives include the study of a uniform government and contractor badging system, uniform access controls to and security for DOE computer systems, and a major new internal program of Operations Security (OPSEC). OPSEC is designed to protect classified and unclassified operations and activities from the inadvertent release of intelligence indicators which are susceptible to hostile intelligence exploitation. OPSEC will operate to raise the awareness of such potential problems and to identify and eliminate potential vulnerabilities.

In addition, we are also taking steps to focus more directly on two important responsibilities. First, our new systems implementation activity will work to ensure that the systems we develop are both cost effective and relevant to the actual protection needs of the DOE's managers. Second, in keeping with our defense-in-depth approach, the deployment of effective safeguards systems needs to be backed up by a comprehensive approach to effectively responding to malevolent attempts against those systems by criminal adversaries. To accomplish this function, we have initiated a Contingency Planning and Response element to plan for and provide the necessary resources for effective response to terrorist incidents involving DOE security interests.

I believe these new initiatives are enabling us to more fully and effectively prepare for, prevent, and if necessary, respond to serious malevolent actions.

Conclusion

In summary, Mr. Chairman, we believe that safeguards and security equipment and systems have been improved in recent years and will continue to improve in effectiveness in coming years. This concludes my statement. I will be glad to answer any questions the Committee may have on the inertial confinement fusion program and the safeguards and security program.

NUCLEAR MATERIALS SECURITY AND SAFEGUARDS

FY 1981 BUDGET REQUEST

(Budget Authority in Millions)

	FY 1980	FY 1981	Change
Operating Expenses	$43.2	$47.0	+ 3.8
Capital Equipment	3.4	3.4	--
Total	$46.6	$50.4	+ 3.8

INERTIAL CONFINEMENT FUSION

FY 1981 BUDGET REQUEST

(Budget Authority in Millions)

	FY 1980	FY 1981	Change
Operating Expenses	$114.9*	$159.5	+44.6
Capital Equipment	8.5	11.0	+ 2.5
Construction	71.5	31.5	-40.0
Total	$194.9*	$202.0	+ 7.1

* Includes $3M pending supplemental budget request.

Senator **Matsunaga**. Thank you very much. Because of the limited available time, in the event that we are unable to ask either of you questions, we will submit them to you in writing. We would appreciate your response in writing for the record and it will appear in the record as though you actually were asked and responded to the questions here at the committee hearing.

Senator **Domenici**. I wonder if I could ask the Chair to indulge me for a moment while I ask the reporter to transcribe for me the last 4 or 5 minutes of Dr. Pewitt's testimony at a very early date? I would like to have that tomorrow morning if I could. If she could identify that before it gets too far along, she might easily extract it this evening. Would that be too much of an imposition?

Senator **Matsunaga**. Ms. Reporter?

The **Reporter**. No, sir. That will be fine.

Senator **Matsunaga**. Dr. Davis, as you know, Hawaii is very much involved in the search for alternative sources of energy, one of which is geothermal and as I see it, and I hope the Department of Energy sees it, geothermal is one of the most promising alternative sources.

Dr. **Davis**. Yes, I would certainly agree with you on that, Mr. Chairman.

Senator **Matsunaga**. As I understand it, the explorations have not been all we had hoped. How many geothermal exploration and production wells were drilled in say 1979?

Dr. **Davis**. Our estimate is around 80 wells.

Senator **Matsunaga**. How many of these have been successful to the point of development, not only into demonstration projects, but nearing commercialization?

Dr. **Davis**. Not much has been done in terms of commercialization. The well drilling has been primarily for exploration purposes. We have about 30 wells that have been classified as producable from the 80 exploratory wells drilled in 1979.

Senator **Matsunaga**. I believe you quoted a figure as to total production in terms of megawatts. What was that figure from the geothermal sources?

Dr. **Davis**. I didn't quote a figure, but we have as our goal to get 3,000 megawatts of electric power equivalent by 1985 from hydrothermal. In terms of direct heat hydrothermal, which we express in quads, and our goal is a tenth of a quad from direct heat applications of hydrothermal by 1985. We project two hundredths of a quad in direct heat application by 1985 for the geopressure resource.

Senator **Matsunaga**. How much of this projection do you have for Hawaii?

Dr. **Davis**. Hawaii is included in the projection. The activity that we have underway in Hawaii at the moment, which is the 3 megawatt wellhead generator, is on the Island of Hawaii and is only using one well. We have that 3 megawatts and possibly a total of 25 megawatts from geothermal in Hawaii by 1985.

Senator **Matsunaga**. That is awfully low, is it not? The initial well, the 3 megawatt, was supposed to have been producing by the first of August. Now, as I understand your testimony, it will not be producing until January of next year. Is that correct?

Dr. **Davis**. It will be early in calendar year 1981. The institute that is responsible for design and development of it is from the University of Hawaii and the project is being done in conjunction with Hawaiian Electric. It is proceeding at a slower pace than we would like to see.

Senator **Matsunaga**. It is my understanding that the one reservoir to which that well reaches has a capacity of 500 megawatts. All you need to do is dig the well and put up the generators. Of course, because of the need for power being on the Island of Oahu rather than on the Big Island, the problem is how to get that power over to Oahu or Honolulu and, as you know, in S. 932, the synfuels bill, we do provide for loan guarantee for laying of cables.

Would that be within your jurisdiction?

Dr. **Davis**. Yes. We have the responsibility in electric energy systems for, in the program that I reported to you before, work in such areas as undersea cables. The responsibility is there because of the technical competence. The funding is provided through the conservation and solar activity and passed through in the Department to my program.

Senator **Matsunaga**. Do you have any setaside for the testing of cables or laying of cables, et cetera?

Dr. **Davis**. We have a program specifically oriented toward what we call underseas electric cable, and it is aimed at the kind of cable that would be laid at 5,000 to 7,000 foot depths and for not too long distances. That program is funded at a level of $1.2 million this year, and since that funding is less than the amount that is needed to pursue even the elementary aspects of cable of this kind, of underseas electric cable, we are trying to get additional funds in later years. It is inadequate at the moment to proceed in pace with the requirement for the transmittal of electricity through underseas cable.

Senator **Matsunaga**. Are the experiments being done in-house or do you have this contracted out for private companies?

Dr. **Davis**. It is primarily contracted out to private companies because it involves the fabrication of cable and it involves the actual laying and testing of cable under stress at these depths of 5,000 to 7,000 feet.

Senator **Matsunaga**. I have discussed this matter with Secretary Deutch as well as a number of his staff who came to my office once relative to research on the Island of Oahu, Honolulu. I think the University of Hawaii has designated five areas for possible geothermal wells, and it was agreed that they would proceed to determine whether those sites would be productive.

Do you have anything lined up in your program?

Dr. **Davis**. We have a contract with the University of Hawaii under which they do conduct the explorations that are needed to delineate possible reservoirs. We have been funding this program for several years and will continue to support these activities.

Senator **Matsunaga**. Thank you.

Dr. **Davis**. They have found more potential reservoirs on Hawaii than the other islands, than they have on Oahu itself.

Senator **Matsunaga**. Senator Church is the chairman of this subcommittee but is occupied with other matters and could not be present and sends his apologies. Senator Church is concerned about the change in acreage leased in 1978 to 1979. He understands it is only 221,880 acres, an increase of approximately 10 percent over 1980, and the story in some states is even less optimistic.

In the State of Idaho, Senator Church's State, there was a decrease of 78,091 acres. The GAO in a recent report prepared at Senator Church's request stated that the main reasons for the slow pace of geothermal development, and I quote, "probably have more to do with economic and technological considerations than other problems."

Do you agree with this assessment or could you explain why the pace of geothermal development appears to be so slow especially in the State of Idaho and, of course, in Hawaii, too?

Dr. **Davis**. It is hard to decide which of the factors of technology, economics, or available resources, or just utility industry reluctance is the principal barrier to the development of geothermal resources. They all play a role. If I had to single out one, I would single out perceived resource reliability, and to a lesser extent, economics, as the primary barriers for industry in developing it on its own. As a result, that necessitates Government intervention in the way that we are so doing through technical assistance and through direct funding, and loan guarantees. So, I would say that these are reasons at the present time for the slow pace of geothermal development.

A steady increase in oil prices make it more atractive. The capricious variation in oil prices, though generally upward, at the moment tends to subtract from the economic attractiveness.

I would point out that the front-end costs of developing geothermal resources, whether they are hot dry rock or geothermal, hydrothermal or geopressure, are often high. We do not have at this time any better estimates for the methane from a geopressured well than the range of $2.50 to $10 per 1,000 cubic feet. We are in the very primitive stages in our technology development and in the assessment of technological costs.

In terms of land availability, most of the geothermal resources, and I do not have the precise numbers at hand, lie on Federal lands. Some of the Federal lands with geothermal potential are continuous to national parks and in these areas we need to develop procedures to protect the important significant thermal features of our national parks and simultaneously expedite the availability of such lands for geothermal development.

Senator **Matsunaga**. Have you any projections as to geothermal electric power? In Hawaii, for example, would it be economical and competitive?

Dr. **Davis**. At the present time, the cost of geothermal in electric power from liquid hydrothermal resources is estimated to range somewhere between $750 and $1,500 per kilowatt hour.

Senator **Matsunaga**. What would that be, in terms of cost per peak watt?

Dr. **Davis**. I don't know what it would be in terms of peak watt. That corresponds to nuclear which runs between $1,000 and $1,100 per kilowatt and small-scale hydro which would run between $1,000 and $2,000 per kilowatt. I think that the economics could not be the principal reason for development of geothermal.

I think the principal reasons are to obtain the diversified energy source that can be utilized locally, is available to be controlled by local utilities, and is not subject to the capricious variations of the market today. I think there are many reasons other than traditional economics for very heavy reliance on the geothermal.

Senator **MATSUNAGA**. Thank you. I have other questions but we will submit them to you in writing.

Now Secretary Sewell, I have one question. I spent almost a day at Lawrence Livermore Laboratory last year. I was very much impressed with the work they were doing in the area of the aluminum air battery, for example. Then, in your area of jurisdiction, I was very much encouraged with the response to my question when will we have nuclear fusion. While earlier I have been told maybe 50 years, I was told maybe within five years. However, I am somewhat disturbed at the delay in the NOVA project there.

What is the justification for that delay? Are the original goals for achieving scientific breakeven in the fusion process still attainable in your view and, if not, what is the expected ratio of energy out of the diffusion to energy on to the target?

Mr. **SEWELL**. Estimates of the amount of energy needed to achieve breakeven have been revised over the last 2 or 3 years with the experiments that have been run at the Shiva facility at Livermore. It is now estimated that it will require more energy than is proposed for the total NOVA project, which is authorized at a level of $195 million. The original estimate for breakeven was set at 300 kilojoules, and the present estimate is that it will take somewhere between three and four times that amount to get to the breakeven point with the fusion experiment.

We should not be discouraged because it is an experimental program, and the estimates that were made originally included that range.

People were really more optimistic than that and hoped that it would be at the low end of the range. Therefore, it frankly was predicted that the total NOVA would reach breakeven. It is now clear from the experiments we have run that that is not the case.

However, NOVA is an important part of our total program. As I was mentioning earlier in the list of experiments that we are proposing, NOVA is one of the key installations with roughly ten times the energy that we now have in Shiva and will operate in the shorter wavelength region that needs to be investigated.

With respect to the budget, in fiscal year 1981 NOVA does have zero funding. To date, we have a total funding of $79 million appropriated out of the 195 million authorized. That will carry us through the fiscal year 1981 time frame. The project will not be stopped.

Senator **MATSUNAGA**. I see, so you do have money in the pipeline?

Mr. **SEWELL**. Yes; there is money in the pipeline now.

Senator **MATSUNAGA**. Sufficient not to delay it in any way?

Mr. **SEWELL**. I was going to say it will delay completion approximately 18 months. Our problem is to balance the resources that we have in the total program to give the best answer across the board. The judgment that we have made is that delaying NOVA and putting the money that we have in hand in other parts of the program is the appropriate thing to do in fiscal year 1981.

Senator **Matsunaga**. One last question—insofar as the problem of what to do with the radioactive waste matter, nuclear fusion as I understand it, would be the answer.

At what projected time will you find the answer?

Mr. **Sewell**. My own personal judgment is that the answer should be clear to us sometime in the 1990's. In both the magnetic fusion area that we referred to in the discussion earlier this afternoon by Doug Pewitt, as well as in the inertial confinement area.

The magnetic area is farther ahead because they have been working on it longer and spending more money on it.

Now as far as application is concerned, once you find the answer it will take a lot of engineering to turn it into a useful powerplant. That time scale will depend primarily on the amount of funds that the country is willing to put into it, but I would estimate that it would take somewhere between 10 and 15 years after finding the fusion answer to have powerplants on line.

Senator **Matsunaga**. Will additional funds hasten finding the answer?

Mr. **Sewell**. Additional funds will hasten it some. However, in my judgment, we are using the resources that this country has in manpower and facilities at just about the upper limit. Additional funds would speed it up some, but not a great deal.

Senator **Matsunaga**. Senator Domenici? I'm sorry I took so much time.

Senator **Domenici**. Not at all, Mr. Chairman; I have a number of questions, but I only have about 5 minutes so I may not get them asked. If I don't, we will submit them to you.

Let me start first, Secretary Davis, and apologize for not knowing who you were. I hope you understand that there has been quite a turnover in the Department of Energy, and I hope I will get to know you. That means I hope you stay for a while and we won't have a reorganization for a bit and we will know precisely what you do, at least that permits any human mind to understand who does what.

With reference to hot dry rock, that isn't a limited potential source of energy, is it?

Dr. **Davis**. Yes. It is not a limited source of energy.

Senator **Domenici**. It has very broed potential in the country, does it not?

Dr. **Davis**. Yes. We don't have the nationwide assessment completed, but potential sites exist in many places across the country. It doesn't have the same kind of boundaries that geopressure methane does.

Senator **Domenici**. I thought you said in your testimony that the budget to this point, absent any additional cuts, would permit us to go ahead with the second pilot in the Fenton Lake area in 1981. Did I misread you?

Dr. **Davis**. I said we had funding in our program for the 20 to 50 megawatt hot dry rock thermal loop program at Fenton Hill, N. Mex.

Senator **Domenici**. They are going to drill a second hole?

Dr. Davis. They are going to drill a second hole in fiscal year 1981, which is required to complete the thermal test loop.

Senator Domenici. As I understand it, the money you requested was ultimately received through OMB. Is that not sufficient for that program to proceed on schedule in 1981, even with a West German commitment which was supposed to be on top, as I understand it? Am I mistaken or is that correct?

Dr. Davis. The program is proceeding according to the planned time schedule. The hot dry rock program is funded in fiscal year 1981 at $14 million, and most of that is for the Fenton Hill activity.

In addition to that $14 million, we have $2½ million maximum coming in from West Germany specifically for the Fenton Hill project, and an additional $2½ million maximum may be made available from Japan for the Fenton Hill hot dry rock project. It is our belief that the program is funded in fiscal year 1981 at an adequate level.

Senator Domenici. That is for the second site?

Dr. Davis. For the 20 to 50 megawatt thermal loop and a second experimental site.

Senator Domenici. Let me ask the question another way. That was the intention in terms of the submittal that it be adequate to keep it on schedule for 1981, for the second site selection and commencement of work thereon?

Dr. Davis. Yes, that is correct. I have been advised that there is a difference between the second well for the Fenton Hill project and the second site. Our program is adequate for the second well and the selection of the second site.

Senator Domenici. All right. That is the program for 1981 and what you submitted was intended to be adequate for that goal in 1981, is that correct?

Dr. Davis. That is correct.

Senator Domenici. Now is it adequate only if the Japanese and who is the third country?

Dr. Davis. The Japanese have just recently indicated their interest in participating at Fenton Hill. The submittal of the budget was done without assumption of any Japanese funding. It was done with the assumption of the West German participation, the availability of West German funding.

Senator Domenici. So it is your testimony that even without the Japanese funding the submittal was supposed to keep it on schedule for second site selection, second hole completion on the original site?

Dr. Davis. Yes, and if the Japanese decide to participate, their funding will also be for the Fenton Hill project, and we would reorient our funding toward the second site selection activity.

Senator Domenici. I have been led to believe it will not be adequate, but I assume that you intended it to be that. Can we ask the appropriators to ask specific questions about the adequacy in that regard?

Dr. Davis. Yes. I think we need to have more detailed discussion on what we mean by adequacy. It is adequate barring unforeseen schedule delays.

Senator Domenici. All right. With reference to the other geothermal activity in New Mexico, the so-called Baca site location, the joint venture with the private sector has some significant promise. I understand the environmental assessment and impact statement has been completed. Is that correct?

Dr. Davis. That is completed, and the status of that process is that we have now asked the Office of Environment to come up with a finding in the record of decision on the objections made by the Indian tribes about infringement on their religious rights.

Senator Domenici. Who is doing that evaluation and under what guidelines, do you remember?

Dr. Davis. The Assistant Secretary for Environment in DOE is doing it, and she is doing it under the general guidelines of the NEPA Act, and in accordance with the American Indian Religious Freedom Act.

Senator Domenici. That would be evaluated against the claim of our Indian people that it would be violative of Indian religious rights?

Dr. Davis. Yes.

Senator Domenici. How long is that evaluation going to take?

Dr. Davis. We had hoped, and so had the Assistant Secretary for Environment, that it would be completed by the end of February. The difficulty has been in determining the national significance tradeoff as opposed to the infringement of the Indian religious rights. We hope for it on a weekly basis. It is a very difficult decision to make.

Senator Domenici [presiding]. Let me ask you then how long do you think it will take, ma'am?

Dr. Davis. The staff of the Assistant Secretary for Environment and my staff working very hard to reach a decision next month. We are working directly with the Indian tribes to attempt to find the compromise solution.

I think the key lies in the Indians being able to, and willing to affect a compromise more than they have in the recent past toward the tradeoff between religious rights and the national development, and construction of this plant.

I am very hopeful and am on a weekly basis, but it is externalities that are beyond my control to govern that particular process, namely, the desires of the Indian tribes.

Senator Domenici. Somebody in the administration outside of the environmental agency is working with the Indian people to see what might be worked out?

Dr. Davis. My staff, in particular, are working directly with the Indian tribes.

Senator Domenici. Dr. Sewell, with reference to the particle beam F-2 upgrade that is taking place there at Sandia, you have confirmed that you want to proceed on schedule with that, if I understand your testimony?

Mr. Sewell. That is correct.

Senator Domenici. I understand the operating funds requested in the budget for 1981 will cause the project not to be able to reach the 1981 desired levels, and that those levels would have to be picked up in 1981. Also, the budget is short somewhere between $2 and $5 million, $3 to $7 million, something in that area. Could you tell us about that?

Mr. Sewell. Let me ask Dr. Schriever to give the details.

Dr. **Schriever.** Senator, when the project was put into the budget, the projections were that $5 million would be adequate in 1981 to carry that project, and both the departmental and administration budget processes included that amount.

Since that time, the Albuquerque Operations Office, which supervises our construction projects, has made a recommendation that, in their engineering judgment, the project would proceed more effectively if a number closer to $10 million were spent in 1981.

We have not attempted to amend that budget because we feel that, in the overall balance of our program, it will be better for us to accept the problems that they feel are caused by that lower level of funding. They believe that the project could be done more efficiently with a little heavier level of funding in the early years.

Senator **Domenici.** And that is, the little heavier level would be moved from 5 to 10?

Dr. **Schriever.** Five to ten in 1981; yes, sir.

Senator **Domenici.** You are reluctant to try to move things around at this late date; is that what you are saying?

Dr. **Schriever.** Not only reluctant at this late date, but in the financial constraints that we are trying to address, we think that is the best way to manage our overall program.

Senator **Domenici.** Thank you very much. Dr. Sewell, there has been some reference in the national media to classification problems that you had out of your safeguard research program. You couldn't find a classification under which to publish a safeguard study on commercial reactors with reference to possible sabotage and damage and therefore that particular research project became known to the public.

Is that still a problem or have you solved that kind of classification problem?

Mr. **Sewell.** I am not clear on the exact study that you are referring to. Are these the handbooks that you referred to?

Senator **Domenici.** Sandia and NRC.

Mr. **Sewell.** You mean the barrier technology type handbook? I'm sorry, I misunderstood your question.

Senator **Domenici.** I probably didn't state it too well.

Mr. **Sewell.** These handbooks are unclassified, and we have been handling them in a careful manner, giving them to the people who need them.

I don't mean by saying that that there is any way we can assure that they do not fall into hands of people outside of those who are authorized to receive them, but we do not supply them to unauthorized people through the normal channels of Government. We give them to the people that request them in the private sector, in the Government sector, and to international people who have need for this information.

You have to recognize that these books address details of construction. For example, that discusses walls and talks about the reinforcing steel; where you put in in the walls, how fast you can get through a wall of varying thickness by blowing holes in it.

The important point is that we give this information to people who need it, who can then use it to design a multiple barrier system for their site; to protect the particular materials. Those site-specific total designs are not released. They are classified. They are protected, and that is the place where the element of surprise or unknown for any adversary that might be trying to get into the facility comes into play. He has to run up against the site-specific unknowns of three booklets like this, plus some other things that may have been added, in penetrating any particular facility that he is after.

Senator **Domenici**. So since that handout is public regardless of how cautious you are, I think you would assume it is public?

Mr. **Sewell**. Yes.

Senator **Domenici**. You are saying you are satisfied that its benefits of being public exceed those of trying to make it more restricted?

Mr. **Sewell**. Yes. I do not see how we could get the information to people who need it if it were classified. That would really restrict it so it could not be used to protect the facility.

Senator **Domenici**. With reference to WIPP, could I just ask you two or three questions?

Mr. **Sewell**. Yes.

Senator **Domenici**. The President now has requested a rescission of $17 million for the WIPP project. It calls for a continuation of "site characterization" even with a rescission.

Now No. 1, if that $17 million were rescinded, will the construction of that large shaft as part of the site characterization proceed in fiscal year 1980–81 or not?

Mr. **Sewell**. If it is rescinded, it probably will not. We will continue to look at it, but there is no decision made yet whether we will be able to start that during the 1980–81 time frame.

Senator **Domenici**. If not, then when?

Mr. **Sewell**. Let me call upon the WIPP project manager, Mr. Gene Beckett, to give an estimate.

Mr. **Beckett**. If WIPP is rescinded, the program would go forward under the commercial repository program.

Senator **Domenici**. If the $17 million is rescinded, Dr. Sewell has said you probably would not proceed in 1980–81 for the construction of the shaft which has been carried on the ledger account as a research site characterization activity. He said it probably would not proceed if rescission of the $17 million occurs.

Mr. **Beckett**. That is correct.

Senator **Domenici**. I say when would it proceed?

Mr. **Beckett**. The earliest would be the middle of fiscal year 1981.

Senator **Domenici**. Could it proceed based upon the President's proposals for a long-term site evaluation for permanent disposal?

Mr. **Beckett**. The people responsible for the commercial program are evaluating whether or not to proceed with an exploratory shaft and on what schedule as they look at the programs for the other potential sites and other potential media.

There are schedules which contemplate proceeding with an exploratory shaft in fiscal year 1981.

Senator **Domenici**. If the $17 million rescission is part of the overall nuclear waste policy and is not approved by the Congress, would we proceed with the shaft site characterization activity in 1980–81 or not?

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Mr. BECKETT. If the decision is not accepted, of course we will proceed with the project as authorized in the fiscal year 1980 authorization. The funding would be sufficient to begin the detailed or title II design of the facilility, and I believe, subject to institutional problems of the environmental impact statement and completing arrangements with the Bureau of Land Management, an exploratory shaft could start toward the end of fiscal year 1980.

Senator DOMENICI. You are referring to the fact that the acreage to be utilized by that construction shaft has changed a bit from 15 to more like 42 and we need an environmental assessment upgrade? Is that what you are referring to?

Mr. BECKETT. No. In order to get access to the land for the shaft, we will have to enter into a cooperative agreement with the Bureau of Land Management. We have not completed that agreement as yet, but the total acreage of the facility has not changed.

Senator DOMENICI. All right. I don't know if this question is for you or Mr. Sewell. In that authorization bill, followed by an appropriation bill, there was a directive in that, Mr. Sewell, that the Secretary of Energy begin to negotiate with the State of New Mexico as to how DOE and New Mexico would interact during the WIPP project?

Mr. SEWELL. That is correct, and that has been started by Mr. Herman Roser, the manager of the Albuquerque Operations Office. He notified me that he had sent off a letter to the Governor's representative in that area to start that process.

Senator DOMENICI. Herman sent the letter telling the Governor's office whatever Mr. Roser thought was required by this statute?

Mr. SEWELL. That is right, to start the negotiation of an agreement with the State.

Senator DOMENICI. Do you know whether or not there is any response to that yet?

Mr. SEWELL. I do not know.

Senator DOMENICI. Mr. Sewell, GAO recently issued a report somewhat critical of the safeguarding of military reprocessing sites.

Does your budget contain adequate resources to ameliorate that situation?

Mr. SEWELL. It certainly does not because the GAO objective is to have a real time capability of following all of the material in processing at the plant. First, of it requires time to develop particular instrumentation and second, resources to build and install the instrumentation. Let me add further that even when that occurs, I do not agree that we will have a 100 percent assurance that we will be following every bit of all of the material in those plants.

Further, the suggestions in the GAO report look to overseas plants in dealing with the IAEA. In my judgment, that is an even larger problem and will take more time and money to accomplish.

Senator DOMENICI. So I take it you do not agree entirely with the GAO criticism of the existing practice?

Mr. SEWELL. I do not agree entirely with it. I can't say that the points that they are raising are completely wrong. They are not. We do not have absolute control over all of the material all of the time. However, we have ideas and have projects under way which will improve our capability to protect and safeguard that material both here as well as through the IAEA in overseas sites. But the relative gain in protection for the types of things that they are talking about and the direction that they are going, I guess we do differ somewhat with them.

Senator DOMENICI. It is safe to say then from the standpoint of your office's expert analysis you have provided resources to comply with the criticisms to the extent that you believe the goals and objectives are achievable and within the parameter of doable as you have defined it? Is that basically what you are saying? Maybe you can tell me again what is wrong with complying with their criticism in toto. It can't be done or it shouldn't be done?

Mr. SEWELL. Both. I think it can not be done in total and certain parts of it I think should not be done.

I think that resources, in terms of manpower and research and development, as well as money to be spent in this area can be expended and gain the objectives that both of us are after in a better fashion than some of the things that they are suggesting.

Senator DOMENICI. Just one last question, Mr. Sewell, and if this is not appropriate for this afternoon you can supply it for me.

There is a reactor support facility which has been justified in schedule 44 of the budget submittals of the Sandia Lab construction data.

Are you aware of that?

Mr. SEWELL. Yes, I am very familiar with that.

Senator DOMENICI. As I read it, I am very disturbed because we seen to want to protect everyone from risks and we are building in a risk for 150, 200 people that we ought to ameliorate with a new improved facility. Yet we are not going to build that. Is that correct?

Mr. SEWELL. That is correct.

Senator DOMENICI. Why aren't we going to build it?

Mr. SEWELL. Primarily for lack of funds, this particular year. I do not disagree with your statement, though. There are 200 people in that area who would be moved into the new building. Relocation would reduce the potential risk to them if we did have difficulty with the reactor.

Senator DOMENICI. I thank you all very nuch for your patience and we will adjourn.

[Whereupon, at 4:49 p.m., the hearing was adjourned, subject to the call of the Chair.]

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DEPARTMENT OF ENERGY FISCAL YEARS 1981-82 AUTHORIZATION

(Civilian Applications)

TUESDAY, APRIL 1, 1980

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
OF THE COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:14 a.m., in room 3110, Dirksen Office Building, Hon. Spark M. Matsunaga, presiding.

Present: Senator Matsunaga.

Also present: Willis Smith, professional staff member.

OPENING STATEMENT OF HON. SPARK M. MATSUNAGA, A U.S. SENATOR FROM THE STATE OF HAWAII

Senator MATSUNAGA. The subcommittee will come to order.

As has been customary, the Subcommittee on Energy Research and Development is holding hearings today to receive testimony from nongovernmental witnesses seeking to express their views concerning the Department of Energy budget for fiscal year 1981. We have a rather lengthy witness list today, with groups presenting commentary on virtually all aspects of the Department of Energy budget.

I would ask each of the witnesses presenting testimony to hold their oral presentation to the time limitations suggested to them in the letter of invitation. This will allow the members of the subcommittee to ask specific questions regarding your testimony and the programs in which you are expressing interest.

I think it is important to note that the recent budget amendment for the Deoartment of Energy has further pared many important programs to levels below last year's appropriated level. However, with the attempts of the administration and the Congress to achieve a balanced Federal budget for fiscal year 1981, it will be difficult to restore funding for many of these programs to a healthy level so as to maintain the momentum that they currently have.

Our first witness today is Senator Hollings, whom I do not see in the audience.

I am informed that Senator Hollings is stuck in the Budget Committee and extends his regrets for not being here. His statement will appear in the record.

[The prepared statement of Senator Hollings follows:]

STATEMENT OF HON. ERNEST F. HOLLINGS, A U.S. SENATOR FROM THE STATE OF SOUTH CAROLINA

Mr. Chairman. I appear before you today in support of continuing the ongoing research and development program at the Barnwell Nuclear Fuel Plant. After saying a few words about the program, I will introduce Dr. James Colby from Allied Chemical and Dr. James Buckham from Allied-General Nuclear Services, who can provide you with more details on the Barnwell program.

I support a fiscal year 1981 research program at Barnwell at a level of $11.5 million. This is the same level of funding as fiscal year 1980 and significantly below the fiscal year 1979 level of $18.5 million. There are two very good reasons to continue this important program. First, the results from the research program to date have been excellent. The Barnwell Plant has developed what many believe to be the most sophisticated nuclear safeguards system in the world. This system is being used for safeguards training of foreign nations and others under provisions of the Nuclear Non-Proliferation Act of 1978. The Barnwell staff has also made significant contributions to proliferation-resistant reprocessing cycles which include the "spiking" of plutonium to make it diversion resistant.

In addition to the beneficial results from the ongoing research program at Barnwell, Congressional support for that program has enabled the owners of Barnwell to maintain a trained staff of experts that are available if decisions are made on the facility's ultimate use. If Congress and the Department of Energy decide to use the facilities at Barnwell in the near term, there must be a staff there to implement the needed program on the fastest possible timetable. While there is some interest in the Congress in using Barnwell for spent fuel storage, the option must also be kept open to use the facility for its intended purpose, which is nuclear fuel reprocessing. Operation of Barnwell as a reprocessing plant would recover the equivalent of a million barrels a day in unused uranium and plutonium from spent nuclear fuel rods. The Administration would have us believe that these rods shoud be stored away forever because of proliferation concerns. Facing the energy crisis that we do, it is inconceivable to me that we would turn our back on an energy source with the potential of Barnwell.

Mr. Chairman, we particularly need to reevaluate our position on reprocessing based on the recently concluded International Nuclear Fuel Cycle Evaluation (INFCE). Other nations are proceeding with reprocessing, irrespective of what the United States does. The INFCE, which had the participation of 66 nations and 5 international organizations, concluded that reprocessing was not an easy route to nuclear weapons production. The nations who are moving ahead on reprocessing want to do so for one very obvious reason—they need the energy in spent fuel.

I urge the Subcommittee to support continuation of the Barnwell program for another year at a level of $11.5 million. To do otherwise would foreclose an option that we can ill afford to lose at this crucial time. With that, let me introduce Jim Colby, who will tell you more about the status of Barnwell and what they are proposing for fiscal year 1981.

Senator **MATSUNAGA**. We will now hear from Dr. L. J. Colby, a senior vice president of Allied Chemical Corp.

STATEMENT OF DR. L. JAMES COLBY, JR., SENIOR VICE PRESIDENT OF ALLIED CHEMICAL CORP., MORRISTOWN, N.J., ACCOMPANIED BY DR. JAMES A. BUCKHAM, EXECUTIVE VICE PRESIDENT OF ALLIED-GENERAL NUCLEAR SERVICES

Dr. **COLBY**. Mr. Chairman, I am accompanied by Dr. Buckham, an executive vice president of Allied-General Nuclear Services. He and I will be pleased at the end of the summary statement to answer your questions.

We have supplied a formal statement for the record. In the interest of time I propose that I briefly summarize that formal statement and answer any of your questions that might arise.

Senator **MATSUNAGA**. Your written statement will appear in the record.

Dr. **COLBY**. For the fiscal years 1978 through 1980, Congress has appropriated funds for research and development programs at the BNFP. This subcommittee has played an important leadership role in providing the necessary funding. Congressional support for R. & D. programs at the Barnwell Plant developed following President Carter's April 1977 decision to defer indefinitely commercial reprocessing, the purpose for which the facility was originally designed and built. The R. & D. funds voted by Congress have: One, produced valuable research results, two, preserved the nucleus of a unique technical staff at Barnwell, and three, maintained the option of using the Barnwell facility productively in the future.

Those of us associated with BNFP are proud of the results of our R. & D. programs. I don't intend to go into these results at this time. However, attached to our formal statement is a detailed writeup on the results from the BNFP research and development program.

Mr. Chairman, several events this year should help define near-term as well as long-term uses for the BNFP.

First, the international nuclear fuel cycle evaluation (INFCE) study has recently concluded. This will allow decisions to be made by the United States and other nations with regard to closing the nuclear fuel cycle.

Second, a congressionally mandated study on possible international and domestic uses for Barnwell is due to be presented by the DOE to Congress this month.

Third, the Congress is also close to making a decision on national policy for away-from-reactor (AFR) interim storage of spent nuclear fuel. Because of the critical need for AFR capacity, especially in the Southeast region, we believe that one of the near-term uses for the BNFP should be interim regional storage of spent nuclear fuel.

Mr. Chairman, the owners of BNFP are reluctant to seek continued R. & D. funding beyond fiscal year 1981. As you know, we are unable to operate the BNFP on a commercial basis. Therefore, our hope is that Barnwell will be transferred to the government on an equitable basis during fiscal year 1981. Actions can be initiated by the Congress now, which will lead to the transfer of the Barnwell facility to the government during fiscal year 1981. We have stated on numerous occasions that we are flexible with regard to the terms and conditions leading to transfer. Also, we are prepared to meet with Government representatives to discuss this matter at their convenience.

The justification for transferring the BNFP to the Government at this time is based on its near-term uses both as an international center for fuel cycle R. & D. including safeguards testing and training and as a regional facility for away-from-reactor interim storage of spent nuclear fuel.

We believe that the BNFP, along with the facilities at Morris and West Valley, can provide regional AFR storage in furtherance of the President's 1977 policy. We believe it is important for DOE's spent fuel storage program to focus on several regional AFR storage sites and not just one.

It is none too soon to begin the long process of acquisition and licensing of facilities for regional AFR storage. Given the uncertainties involved, it would be extremely difficult for the Government to acquire, license, and place in operation additional AFR storage by 1983.

The Department of Energy has stated that this 1983 requirement can only be met by acquiring existing AFR storage sites. A new AFR site will, according to the DOE, take 8 years to construct, license, and place in service. Therefore, it is in the national interest for the Congress to authorize DOE to begin negotiations promptly to acquire existing facilities suitable for regional AFR storage.

A fiscal year 1981 research and development program at Barnwell is necessary to continue some important ongoing R. & D. programs and maintain key staff until the BNFP is transferred to the Government. I would categorize the proposed fiscal year 1981 program as a minimum sustaining program which bridges the gap between the initiation and consummation of transfer.

A fiscal year 1981 minimum sustaining program for the BNFP can be carried out for $11.5 million. This is the same level of funding that Congress appropriated in fiscal year 1980 for the Barnwell R. & D. program and significantly below the fiscal year 1979 level of $18.5 million. When inflation is taken into account, it is about one-half the fiscal year 1979 program level.

Mr. Chairman, we propose that a Government-funded program for fiscal year 1981 be continued at Barnwell in the two most important tasks that are currently underway. These are nuclear safeguards development and spent fuel transportation, handling, and storage. Our formal statement discusses these tasks in detail.

In conclusion let me again emphasize that if the potential of the BNFP is to be realized, the facility should be transferred to the Federal Government during the next fiscal year. It is not in the interest of the Government or the owners of the BNFP to prolong the status quo. We urge the subcommittee to maintain a minimum R. & D. program at Barnwell in fiscal year 1981 in the amount of $11.5 million. We also would urge that this subcommittee initiate those actions necessary to transfer the BNFP to the Federal Government during the coming fiscal year.

Mr. Chairman, this concludes my statement and I am available, along with Dr. Buckham, to answer any questions that you or other subcommittee members might have.

[The prepared statement of Dr. Colby follows:]

STATEMENT SUBMITTED TO
THE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
ENERGY AND NATURAL RESOURCES COMMITTEE
UNITED STATES SENATE

ON

THE PROPOSED FY 1981 BARNWELL PROGRAM

APRIL 1, 1980

BY

L. JAMES COLBY, JR.
SENIOR VICE PRESIDENT
ALLIED CHEMICAL CORPORATION

AND

JAMES A. BUCKHAM
EXECUTIVE VICE PRESIDENT
ALLIED-GENERAL NUCLEAR SERVICES

Chairman Church and Subcommittee members, my name is L. James Colby, Jr. I am a Senior Vice President with Allied Chemical Corporation. Allied Chemical, through Allied Chemical Nuclear Products, Inc., is a 50 percent owner of the Barnwell Nuclear Fuel Plant (BNFP) in South Carolina. The General Atomic Company, through its partnership in Allied-General Nuclear Services, owns the remaining 50 percent of the Barnwell plant. I am accompanied by Dr. James A. Buckham, Executive Vice President of Allied-General Nuclear Services.

CURRENT STATUS OF BARNWELL NUCLEAR FUEL PLANT

For the fiscal years 1978 through 1980, Congress has appropriated funds for research and development programs at the BNFP. This Subcommittee has played an important leadership role in providing the necessary funding. Congressional support for R&D programs at the Barnwell Plant developed following President Carter's April, 1977 decision to defer indefinitely commercial reprocessing, the purpose for which the facility was originally designed and built. The R&D funds voted by Congress have: (1) produced valuable research results, (2) preserved the nucleus of a unique technical staff at Barnwell, and (3) maintained the option of using the Barnwell facility productively in the future.

Those of us associated with the BNFP are proud of the results of our R&D program. The BNFP staff is developing what many believe to be the most sophisticated nuclear safeguards system in the world. This system is being used for safeguards training under provisions of the Nuclear Non-Proliferation Act of 1978. In the areas of nuclear fuel reprocessing, the Barnwell staff has studied proliferation-resistant reprocessing cycles. Out of these studies have come recommendations that involve treating or "spiking" plutonium to make it more proliferation-proof and blending plutonium with uranium to make its diversion for weapons use more difficult. In the transportation and spent fuel storage area, studies conducted at Barnwell will result in improved techniques for shipping and storing spent fuel. With the deferral of reprocessing and the resultant increase in the need to store spent fuel, it is essential that new and improved methods of spent fuel storage be developed. Attached to this statement is a detailed writeup on the results from the BNFP research and development program.

Mr. Chairman, several events this year should help define near-term as well as long-term uses for the BNFP. The International Nuclear Fuel Cycle Evaluation (INFCE) has been recently concluded. As you know, this was a 2 1/2-year, 66-nation evaluation of the proliferation risks associated with nuclear energy development. A Congressionally mandated study on possible international and domestic uses of the BNFP is due to be presented to Congress this month. We continue to believe that the Barnwell facility and staff are assets of national and international importance and hope that this forthcoming report on Barnwell will identify programmatic near-term and long-term uses for the Barnwell facility and staff under government ownership.

The Congress is also close to making a decision on national policy for away-from-reactor (AFR) interim storage of spent nuclear fuel. Because of the critical need for AFR capacity, especially in the Southeast region, we believe that one of the near-term uses for the BNFP should be interim regional storage of spent nuclear fuel.

Mr. Chairman, the owners of the BNFP are reluctant to seek continued R&D funding beyond FY 1981. As you know, we are unable to operate the BNFP on a commercial basis. Therefore, our hope is that Barnwell be transferred to the government on an equitable basis during FY 1981. Actions can be initiated by the Congress, now, which will lead to the transfer of the Barnwell facility to the government during FY 1981. We have stated on numerous occasions that we are flexible with regard to the terms and conditions leading to transfer. Also, we are prepared to meet with government representatives to discuss this matter.

TRANSFER OF THE BNFP TO THE FEDERAL GOVERNMENT

The justification for transferring the BNFP to the government at this time is based on its near-term uses both as an international center for fuel cycle R&D and safeguards testing and training in the post-INFCE period and as a regional facility for away-from-reactor (AFR) interim storage of spent nuclear fuel.

With the conclusion of the INFCE, nations such as Japan, the United Kingdom, and France are announcing their plans to proceed with nuclear fuel reprocessing programs. Other less-developed nations are considering the reprocessing option. The United States must remain in the forefront of reprocessing technology in order to help reduce the risks associated with nuclear proliferation. It is, therefore, imperative for the United States to initiate at a minimum a comprehensive R&D program to refine techniques for making reprocessing more proliferation-resistant, safeguarding plutonium, and managing the high-level nuclear wastes that come from the reprocessing of spent nuclear fuel.

An international role for Barnwell is consistent with the recent outcome of the INFCE, which concluded that the multinational and international fuel cycle center concept is an attractive nonproliferation approach. In the safeguards area, the INFCE concluded that international safeguards methods and techniques are essential for all stages of the fuel cycle and that further development and improvement of existing safeguards methods and techniques are necessary for future fuel cycle facilities.

The government should utilize the Barnwell Plant for the purpose of serving as an international nuclear fuel cycle research center. As a part of this effort, the BNFP could serve as a safeguards testing and training center to allow the sophisticated nuclear safeguards system there to be used and adapted to future facilities. Such a use would be in keeping with a recent General Accounting Office (GAO) report to Congress entitled "Nuclear Fuel Reprocessing and the Problems of Safeguarding Against the Spread of Nuclear Weapons." The report concluded that:

> "GAO concluded that the administration's policy has hampered research and development of ways to safeguard against the diversion of nuclear material from reprocessing plants for non-peaceful purposes. New technology is needed if the United States is to further its own goals of preventing the spread of nuclear weapons and influence other countries to adopt strengthened safeguards at reprocessing facilities."

That report went on to recommend that:

> "The Secretary of Energy should direct the Office of Safeguards and Security to ... demonstrate integrated safeguards systems for commercial and international application."

An additional near-term use for the BNFP is for interim regional storage of spent nuclear fuel. There has been a growing interest in the Congress and the DOE in using the BNFP for regional spent fuel storage. Today, there are facilities at Morris, Illinois, and West Valley, New York, which are serving as away-from-reactor spent fuel storage facilities. In October, 1977, President Carter announced a policy whereby the government would take title to utility spent fuel and provide needed AFR storage capacity. Following the announcement of this policy, the Department of Energy surveyed the 19 existing government storage facilities, many of which are still operating, to determine their possible use for storage of commercial spent fuel. The Department concluded that none of these sites could be used because they were not designed or constructed for the licensed storage of commercial spent fuel.

We believe that the BNFP, along with Morris and West Valley, can provide regional AFR storage in furtherance of the President's 1977 policy. We believe it is important for DOE's spent fuel storage program to focus on several regional AFR storage sites and not just one. The great advantage to using the BNFP for regional AFR storage is the heavy dependence of the Southeast on nuclear energy. Several reactors with potential spent fuel storage problems are located in the Southeast region of the United States.

It is none too soon to begin the long process of acquisition and licensing of facilities for regional AFR storage. Given the uncertainties involved, it would be extremely difficult for the government to acquire, license, and place in operation additional AFR storage by 1983. The Department of Energy (DOE) has stated that there is a need for at least 240 and possibly as much as 1140 metric tons of uranium (MTU) of AFR storage capacity by 1983. The Department has also stated that this need can only be met by acquiring existing AFR storage sites. A new AFR site will, according to the DOE, take 8 years to construct, license, and place in service. Therefore, it is in the national interest for the Congress to authorize DOE to begin negotiations promptly to acquire existing facilities suitable for regional AFR storage sites.

To elaborate further on AFR scheduling problems, I would like to mention some of the timing implications involving the use of the BNFP for regional AFR storage. We believe that a license application would have to be submitted to the NRC no later than the fall of 1981 in order for the BNFP to be operating as a regional AFR facility in early 1984 at a capacity of 1750 MTU. This schedule assumes no delays due to protracted intervention.

If it became essential to store spent fuel at the BNFP in 1983, a cask unloading pool could be utilized to store up to 120 MTU on a temporary basis. This assumes that interim licensing would be available.

Other longer term uses for the BNFP include eventual reprocessing of LWR fuels, should the present policy of deferral change at some future date. However, it will take significant time and additional investment to implement a decision to go forward with reprocessing under government sponsorship. Actual reprocessing of commercial fuels would not occur for 6 to 10 years following the decision to proceed, due to licensing requirements and the need to construct additional facilities. In the interim, the existing Barnwell reprocessing plant should be maintained as a backup for processing of government fuels.

PROPOSED FY 1981 BARNWELL R&D PROGRAM

A FY 1981 research and development program at Barnwell is necessary to continue some important ongoing R&D programs and maintain key staff until the BNFP is transferred to the government. I would categorize the proposed FY 1981 program as a minimum sustaining program which bridges the gap between the initiation and consummation of transfer.

A FY 1981 minimum sustaining program for the BNFP can be carried out for $11.5 million. This is the same level of funding that Congress appropriated in FY 1980 for the Barnwell R&D program and significantly below the FY 1979 level of $18.5 million. As in the past, these funds provide for no return on investment to the owners. no fee, and essentially no depreciation. We believe that the program we are proposing will provide continuity of effort and will retain many of the vital resources at Barnwell, although the proposed program will support only two-thirds of the current staff at Barnwell. We are working on the possibility of alternative assignments for those not covered by the proposed program.

Mr. Chairman, we propose that a government-funded program for FY 1981 be continued at Barnwell in the two most important tasks that are currently underway.

Over three-fourths of our $11.5 million request would be applied to the continuation of the safeguards evaluation task now underway at the BNFP. This task will require a disproportionate share of the funds because portions of the facility must be operated using natural uranium solutions. The purpose of this safeguards task will be to complete work on the development of an advanced safeguards system that could be used in fuel cycle facilities around the world.

Specifically, we would continue the installation and testing of safeguards hardware developed at the DOE national laboratories. Some of this testing will require operating portions of the plant where components of the computerized nuclear material control and accounting system need integrated testing.

Also, we propose to complete testing of the physical security system, including voice verification, video observation, motion and intrusion detection, access control and verification, and alarm testing. This system is intended to provide adequate protection against covert or overt intrusion.

Lastly, we propose to continue experimental studies on solvent extraction to obtain safeguards-related information on the use of pulse columns in solvent extraction systems. This work is necessary to provide the enhanced measurement capabilities required to demonstrate advanced safeguards concepts. At the conclusion of the FY 1981 development and testing program, AGNS would be in a position to develop final criteria, specifications, and documentation for an advanced integrated safeguards system with applicability to both existing and future fuel cycle facilities around the world.

The balance of the program will focus on spent fuel handling, storage, and transportation studies. This proposed program would not only provide DOE with site-specific information on cask handling, transportation, and storage, but would also maintain the staff at Barnwell that would be essential to the implementation of an interim, regional AFR storage program there.

In conclusion, Mr. Chairman, let me again emphasize that if the potential of the BNFP is to be realized, the facility should be transferred to the federal government during the next fiscal year. It is not in the interest of the government or the owners of the BNFP to prolong the status quo. We urge the Subcommittee to maintain a minimum R&D program at Barnwell in FY 1981 in the amount of $11.5 million. We also would urge that this Subcommittee initiate those actions necessary to transfer the BNFP to the federal government.

Mr. Chairman, this concludes my statement and I am available, along with Dr. Buckham, to answer any questions that you or other Subcommittee members might have.

2/25/80

SUMMARY OF RESULTS OF THE RESEARCH AND DEVELOPMENT PROGRAM AT THE BARNWELL NUCLEAR FUEL PLANT

(Fiscal Years 1978-80)

Under contract with the Department of Energy, Allied-General Nuclear Services has carried out a productive program of research and development at the Barnwell Plant in support of the Government's nonproliferation objectives. Results of this work will be of benefit to the nation whether spent fuel is ultimately to be reprocessed and recycled or disposed of as waste. A brief summary of a portion of this work, more fully described in detailed reports to the DOE, is set forth in the following paragraphs.

Safeguards - "Safeguards" -- which embraces both accountability for special nuclear material and its physical protection from sabotage, theft, and diversion -- has become a keystone to the further development of peaceful uses of nuclear energy. Under the DOE contract, AGNS is achieving notable success in developing an effective system which, if applied to nuclear fuel cycle facilities throughout the world, would materially reduce the possibility of illicit nuclear weapons proliferation.

The Advanced Integrated Safeguards System, which AGNS is developing under its DOE contract, includes highly sensitive computerized analytical instruments for continuous monitoring and accounting for all special nuclear material wherever it may be located in the facility. These instruments are interconnected through a number of minicomputers to a physical protection system, with subsystems which include voice verification, video observation, motion and intrusion detectors, access controls and verification, and alarms. Under the FY 1980 DOE contract, AGNS is developing and incorporating into the presently installed safeguards demonstration system additional components and testing them in integrated operation.

The AGNS Safeguards System, as presently installed in a modern, commercial scale, noncontaminated fuel cycle facility, makes the Barnwell Plant a unique asset for hands-on training of domestic government and industry safeguards personnel. In addition, because the well-established Barnwell Plant design eliminates any concern as to compromising sensitive reprocessing information, the facility is also uniquely suited for fulfillment of U. S. obligations, required by Section 202 of the Nuclear Non-Proliferation Act of 1978, to provide safeguards training for foreign nationals. Under its DOE contract, AGNS has already commenced to provide a portion of such training.

AGNS has issued numerous reports to the DOE concerning this Safeguards System and its components. The favorable reception of these reports is indicative of the high quality and effectiveness of this aspect of AGNS development work.

Fuel Processing Studies - Concern about conventional commercial reprocessing has centered upon the possible illicit diversion of plutonium from uranium-based fuels with resultant proliferation of nuclear weapons. Much of the work conducted for DOE at the Barnwell Plant has been directed toward study and development of proliferation-resistant fuel processes. This work has included thorium-based as well as uranium-based fuel cycles.

Flowsheets were developed and laboratory studies conducted to demonstrate separation of thorium and uranium from thorium-based fuels used in light water reactors. Modifications to conventional separations plant designs, to adopt them to this alternative fuel cycle, were identified. AGNS also developed the concept of a plutonium-238 "heat spike" which would complicate design, fabrication, and assembly of a nuclear explosive device made from diverted plutonium. Work during FY 1979 demonstrated the technical feasibility of the "heat spike" concept and identified the attendant modest fuel cycle cost penalties. This work received favorable mention in publications of the American Nuclear Society.

Additional R&D activities conducted throughout FY 1978-1979 and continuing in FY 1980 have centered on coprocessing and radioactive spiking to enhance the proliferation resistance of the conventional uranium-based fuel cycle. Development of the conceptual design for coprocessing has entailed creation of overall site plans and cost estimates for the required individual major separations, conversion, and waste facilities. Data required to support the conceptual design have been developed both from cold chemical runs, which have demonstrated that the Barnwell Plant could readily be adapted to coprocessing and from laboratory experiments. The data generated in these studies have been useful in reprocessing programs at Oak Ridge and in safeguards development work at Los Alamos. Indeed, a recent Los Alamos report states that it is essential that these experiments at Barnwell continue.

Spent Fuel Storage and Transportation - The continuing indefinite deferral of commercial reprocessing in the United States has resulted in an increasing buildup of spent fuel at reactor sites throughout the country. Regardless of whether spent fuel is, by national policy, to be reprocessed and recycled or discarded as waste material, urgent action is needed to prevent congestion at reactor sites from resulting in the shutdown of numerous nuclear power plants. Solution of this problem will require not only continued expansion of storage capacity at reactor sites and a Federal program to provide Away-From-Reactor storage pools (AFR's), but also increased capability to handle and transport fuel between such locations.

Under its DOE contract, AGNS is conducting studies and development work which are of material benefit to improved efficiency of such spent fuel handling, transportation, and storage. Based on actual testing of spent fuel transportation equipment, AGNS has assessed the capability of the existing fleet of U. S. shipping casks, reporting on unloading times, manpower requirements, and the potential for radiation exposure. AGNS is presently developing techniques for reducing cask unloading times and exposures. AGNS has also developed a conceptual design for the highly specialized equipment and servicing facilities needed to meet the rigorous maintenance requirements of spent fuel shipping casks. This work has been particularly well received with numerous copies of pertinent reports requested by Congressional staff members, National Laboratories, and DOE contractors. AGNS has also effectively critiqued the spent fuel cask handling facilities of the proposed Federal waste repository and is participating with DOE in a program to determine appropriate handling, transportation, and storage of the damaged core from the Three Mile Island reactor.

At DOE's request, AGNS has estimated the capacity, lead times, and costs for utilizing the Barnwell Plant in various configurations for AFR spent fuel storage. Fuel disassembly has been investigated as a means of consolidating fuel and thus increasing capacities of AFR's. Such fuel disassembly and consolidation has been shown to provide additional cost benefits in packaging, transport, and disposal of spent fuel at a Federal repository.

Senator **Matsunaga**. In proposing the transfer of Barnwell facilities to the Federal Government, do you feel that the Federal Government would be getting a fair deal at the suggested $11.5 million?

Dr. **Colby**. The $11.5 million is the cost of an R. & D. program which would include no fee, no depreciation and no return on capital. It essentially just pays the bills of the staff and accomplishes R. & D. programs that are of specific interest to the Federal Government. It is not a program that would be buying the facility. The facility program would be quite different.

Senator **Matsunaga**. What would the transfer of the facilities cost?

Dr. **Colby**. We have had discussions during the past 2 years with the Department of Energy, very brief and very informal. They have stated to us that they are not allowed or have chosen not to sit down and negotiate with us until Congress tells them to do so. We don't have a figure that we can tell you this is what was negotiated. I have provided a listing indicating our investments in the plant totaling $362 million as of the end of 1978. That is a little over $200 million in capital, additional costs in preoperating expenses, taxes and, of course, interest on double amount bonds. So that we have a capital account, we have an interest account which is real cost, and we have the preoperating expense, net of taxes.

We have indicated a high degree of flexibility with regard to what form this could be taken in or what time frame, and we know that—we believe that the facility is excellent. It operates very well in the cold mode. Its replacement value in today's market would be $500 or $600 million as a reprocessing plant. As you know, the President has chosen to defer reprocessing. We believe that decision will be reviewed during the next few years and that should reprocessing be chosen under Government ownership I believe that the Government would be getting an extremely fine buy and a very good facility. It is the kind the Japanese want to buy and the type of technology the Japanese want to have. They have come to us as a private company and asked if we can license them. We have told them no, because the Government has withdrawn our right to license these to others outside. Its value is important as a licensing value as well.

Senator **Matsunaga**. The GAO recently criticized the DOE regarding the safeguards in the security practices at military reprocessing facilities, and stated that more R. & D. needs to be done. Is the Barnwell facility a good place to perform this R. & D.?

Dr. **Colby**. Part of that R. & D., development, even some of the work we have done so far during the past 3 years is very worthwhile and can be applied to existing plants, both in this country, such as our military facilities and those facilities in other countries, such as France and the United Kingdom, and even in Japan.

The idea behind safeguards is that one develops well known and reliable instrumentation and methods for accountability and ties these back into the operation of the plant. We have prided ourselves in the development of the safeguard system at Barnwell in that we believe the system we have actually assists in the operation of the plant, that it is not a deterrent and, therefore, a burden to run. It is actually a desire to run on an operating plant because it keeps the plant well tuned and tells us where everything is in the facility.

Senator MATSUNAGA. It is my understanding that at the 70-odd nuclear powerplants in the United States about 2,100 tons of nuclear radioactive waste matter is produced. What is the capacity of Barnwell to reprocess? Could it handle all of the waste matter which is emitted by all the powerplants in the United States?

Dr. COLBY. Well, we have 72 powerplants today operating in the United States. They are of different sizes. I believe there are about 50,000 megawatts installed. At that level of power production the United States generates about 1,500 tons of spent nuclear fuel. Some would call it a resource.

Senator MATSUNAGA. How much did you say?

Dr. COLBY. 1,500 tons of spent nuclear fuel per year. Some would call that a resource since it is worth about 1 million barrels of oil per day equivalent; others might call it waste. I choose to call it a resource.

Barnwell was designed with the idea of processing 1,500 tons of fuel per day per year. It is a world-scale plant in that others are looking at building the same size, roughly 1,500 tons per year capacity.

Senator MATSUNAGA. Where do you get the 1,500 tons figure? I was given 2,100 tons by the Department of Energy.

Dr. COLBY. I don't know the discharge rate. I know that if one has a 1,000 megawatt reactor running at the conditions of 70 percent powerload, that it generates 30 tons a year. If one has 50 of those reactors operating that would be 1,500. The United States has 72 reactors, but they are of different size and of different application, so it is quite possible that the Department of Energy numbers and my numbers would be a little bit off, but they are the right order of magnitude.

Dr. BUCKHAM. Part of the reason for the discrepancy is the difference in the burnup of fuel associated with the estimates, and actually 1,500 tons a year comes out of burnup by 50,000 megawatts of reactors. If you don't operate every core to the fullest it will be some additional tonnage per year and that is probably the reason for the higher number the Department of Energy gave you.

Dr. COLBY. We do not know exactly what our capacity is since we have not run the plant in a hot mode. We ran it cold for 2½ years and found that it runs at 6½ tons a day rather than its design rate of 5. Our assumption was 5 tons a day, 300 tons a year with down time. If it is 6½ tons a day, 300 days operation, it would meet the requirement of the existing plants.

Senator MATSUNAGA. You don't go into any experiments for nuclear fusion, do you, at your plant?

Dr. COLBY. No, we do not. It is a single purpose facility for reprocessing and recycling of nuclear fuel.

Senator MATSUNAGA. And a reprocessing product would be plutonium?

Dr. COLBY. The products would be uranium for recycle and plutonium for recycle or storage in the breeder and waste as a solid product. Those are the products leaving the plant. One could envision spent fuel elements moving to the plant and fuel elements for recycle leaving the plant with canisters of waste leaving to the repository.

Senator **Matsunaga**. The waste matter would be what percentage of the waste matter which you take for reprocessing?

Dr. **Colby**. I need that clarified.

Senator **Matsunaga**. You say the reprocessing will also produce waste matter.

Dr. **Colby**. Yes.

Senator **Matsunaga**. What percentage is that waste matter to the matter you take in for reprocessing?

Dr. **Colby**. There are several answers to this question, because there are several definitions of nuclear waste, different levels. Let's start with the high-level waste, the kind that has to go into the repository and is radioactive for 500 years, at least, and has a concern. If we compare the fuel elements coming in as a waste matter and compare the product leaving a reprocessing plant, just the fission products, one gets a volume reduction of about a factor of 6 in the volume. The spent fuel is reduced by about a facot of 6 when compared to the volume of the high-level waste leaving the facility going to the repository.

On the other hand, when one operates this plant one contaminates materials such as clothing, so that the actual physical volume of some of the low-level waste may be larger than the volume of fuel elements coming in.

However, I would hasten to mention that if one just compares waste volume at that point it is misleading. The largest single low-level waste that is created by the fuel cycle is in the uranium mill tailings with the uranium. When one reduces that it reduces substantially the low-level waste volume as well.

Senator **Matsunaga**. By substantially, what percentage?

Dr. **Colby**. By 35 percent or more. The amount of uranium is reduced by 35 percent. Therefore, the amount of mill tailings would be reduced by 35 percent and the volume of mill tailings is very large, 100 times the volume of low-level materials coming from a reprocessing plant.

Senator **Matsunaga**. Thank you very much.

Dr. **Colby**. I would like to enter a brief comment concerning Senator Hollings, and that is on behalf of all the employees of Allied-General Nuclear Services I would like to express our deep appreciation to him for his continuing support of the Barnwell R. & D. program. His strong leadership has been essential in keeping the Barnwell team together while alternative uses for the facility are explored.

Thank you.

Senator **Matsunaga**. Our next witness is the president of the National Coal Association, Mr. Carl Bagge.

STATEMENT OF CARL E. BAGGE, PRESIDENT, NATIONAL COAL ASSOCIATION, WASHINGTON, D.C., ACCOMPANIED BY DR. JOSEPH J. YANCIK, VICE PRESIDENT OF RESEARCH

Mr. **Bagge**. I have a formal statement also which we have supplied for the committee. I will try to highlight it in the interest of saving time.

Senator **Matsunaga**. Your statement will appear in the record.

Mr. BAGGE. Mr. Chairman, my name is Carl E. Bagge. I am president of the National Coal Association which represents coal producers, equipment manufacturers, suppliers, consultants, coal sellers, and other service organizations providing technical and financial services to the coal industry.

Briefly, in my statement I cover four points:

First, I discuss the need for additional research on health and environmental effects of coal.

Second, I comment on the adequacy of the overall DOE budget for coal R. & D.

Third, I explain our reasons why we believe there are inadequate funds for direct combustion of coal.

Finally, I comment on and recommend reversal of the planned reduction in Federal funding for coal mining R. & D.

On pages 2 and 3 I discuss the health and environmental effects of coal production and use. While your subcommittee is not directly involved we are certain your attention has been called to health and environmental effects of increased coal use. For example, increased media and public attention has been focused on concerns about acid rain and a potential buildup of carbon dioxide in the atmosphere due to the combustion of fossil fuels. Much has been written about these subjects. We urge the subcommittee not to lose sight of the fact that the more knowledgeable and objective writers are coming to the conclusion that not enough is known to determine whether the concerns are, in fact, real problems.

The scale of research that is needed to determine whether there are problems far exceeds the resources of industry and there is the added problem that industry research findings on issues such as these are often regarded skeptically.

For these reasons there is a strong need for Government research funding on issues involved in health and environmental effects of increased coal use. We would urge you to seek your colleague's support for increased Federal funding for research on these issues.

The coal industry has also increased its research efforts. Specifically, the NCA is funding a project at Bituminous Coal Research Inc, (BCR), which provides a continuing review of factual information and research findings on such issues as acid rain and CO_2. We believe the results of these projects will be useful contributions to the dialog on health and environmental issues.

Also, NCA and BCR are following closely the work of the Electric Power Research Institute (EPRI) which has a major research effort focused on health and environmental effects of coal use.

We are pleased that the President's 1981 budget request for the Department of Energy shows a substantially increased commitment for coal-related research and development. Coal R. & D. has long been neglected in the Federal Government's R. & D. priorities and we, therefore, regard the request for a 39-percent increase in funding over 1980 as a favorable signal from the administration.

We would note, however, that a large increase in funding is due principally to the fact that promising technologies being supported by the Government have moved to the point where construction of demonstration plants is now necessary. Thus, while the overall level of the request is promising, there are particular program areas where funding is inadequate.

I now turn to the last two points which are of particular concern to us.

On page 4 we deal with the inadequate funding for direct combustion of coal. Our review of the DOE budget indicates that there is a significant decrease in DOE's commitment to the demonstration of technologies which permit clean burning of coal. Specifically, we would note the apparent termination of fluidized bed combustion boiler demonstrations for major industrial plants and the deemphasis of accelerated testing and demonstration of advanced flue gas desulphurization systems.

Both of these actions appear contradictory to the administration's emphasis on the clean burning of coal. Both programs offer near-term potential for increased use of coal in an environmentally sound manner. These technologies, when available, could permit a substantial reduction in the Nation's current dependence on oil and natural gas for electric power generation and process heating uses.

We urge the committee to review these reductions carefully and to provide sufficient funds in DOE's 1981 authorizations.

Finally, we come to what I believe is the most important element of our concerns, the substantial reduction in funding for coal mining technology R. & D..

The second area of our concern is the proposed reduction from fiscal year 1980 funding levels of $22.3 million in DOE's funding for coal mining technology R. & D.—from $68.8 million in fiscal year 1980 to $46.5 million in fiscal year 1981. As I said, this was cut further by the announcement over the weekend of $14 million, a total loss to this critical coal mining research and development program of $36 million, which, in my view, virtually emasculates the program. The budget for DOE would reduce underground mining R. & D. by $17 million—from $43 million to $26 million, and reduce surface mining R. & D. by $5 million—from $13 million to $8 million.

The coal industry has plenty of capacity to produce the coal that is now needed in the United States and for exports and can accommodate a substantial increase in demand. However, it should be noted that there will be a continuing need for the development and use of advanced mining technologies as the demand for coal increases, as it is necessary to extract coal from thinner or less accessible coal seams, and in order to meet increasingly restrictive health and environmental requirements related to coal mining. It is particularly important to note this need for advanced mining technologies now since there is normally a very long leadtime before newer technologies can be developed, demonstrated, and brought into widespread use in the coal mining industry.

Because of these needs, we are greatly concerned about the administration's proposal to sharply reduce DOE funding for mining technology. DOE has not explained publicly its justification of these cuts. They certainly are not justified by any recent breakthroughs which would provide the basis for reduced R. & D.

I would like to make five points which we believe support the need for close scrutiny by your subcommittee of the administration's proposal and for restoring the proposed funding reductions.

The rest of the paper is devoted to five substantive points which we believe support the need for close scrutiny by the subcommittee of the President's proposal and restoring the proposed funding from 1980, $68.8 million.

Federally funded mine technology programs are needed to complement the mining R. & D. efforts supported by private industry. Research and development by the private sector has been increasing steadily. The increasing effort is due in part to the DOE program since many DOE projects involve cost-sharing or inmine testing—both of which require mining company involvement and often a substantial cost to the mine operators. BCR is now completing a survey, conducted jointly with the Department of Energy, of coal industry mining R. & D. programs and expenditures. The results of the survey have not been fully analyzed, but there appear to be several significant findings. For example:

Companies producing 500,000 tons of coal or more annually spend an average of about 16 cents per ton of coal mined on R. & D.—for a total of $80 million in 1978. Those producers mine about 76 percent of United States coal production.

A majority of the expenditures supported demonstration-type projects which involve equipment or a minor modification of a mining technique.

In underground operations, a large part of these efforts were directed toward health and safety objectives.

In surface mining operations, the efforts focused on reclamation or environmental objectives.

For both types of mining the predominant goals appear to be a search for more cost-effective ways to operate in full compliance with regulations under difficult mining conditions.

R. & D. expenditures by equipment manufacturers and suppliers were focused on development projects. Which about one-half of the 70 largest equipment companies responding to the survey, a total expenditure of $47 million was reported. Few specifics on these R.&D. expenditures were reported because of the competitive nature of the work, but it appeared that most efforts were directed toward improving existing product lines. Some innovative mining machine projects were mentioned but few details were given.

In summary, the survey confirmed that the primary focus of private sector R. & D. is on near-term improvements in existing equipment and techniques and on solutions to compliance problems rather than on the development of innovative technologies.

Longer range innovative technology development projects are needed and the industry must look to federally funded programs to fill this gap—particularly during the period when industry efforts must be focused on compliance with increasingly stringent health and safety and environmental requirements.

The development of new or significantly improved coal mining system technologies requires a series of steps extending over a lengthy period of time. Prior to 1970, a 10- to 15-year timespan was commonly experienced for the development and introduction of new mining methods or significantly new mining equipment. Since

1970, the time required for a major new mining technology to achieve commercial status is more like 20 to 25 years—due largely to extensive Federal and State health, safety, and environmental legislation and regulations imposed on mining operations.

Undertaking such a long-term financial risk by the private sector in the development of innovative mining systems is clearly beyond a reasonable business risk, and most likely far beyond the capacity of the coal industry under present economic conditions.

DOE has recognized the need for a strong federal role in supporting long-term developments in the coal use technology area. Also, DOE has undertaken some very high risk developments of alternative renewable energy fuels. However, the 1981 budget in particular ignores this same responsibility for the coal mining technology.

Because of its importance to the coal mining industry, the BCR Production Research Committee reviewed the DOE's mining technology program plan and the goals and objectives of major projects in the DOE program. The Production Research Committee is eminently qualified to make this review since it is composed of experienced senior level coal executives who have operating and management responsibilities and are aware of present mining problems. They are also cognizant of future problems that are likely to be encountered when domestic production reaches the level of 1 to 2 billion tons annually.

The committee concluded that the DOE program plan is generally sound but underfunded in several critical program areas. Underfunded areas include longwall mining systems, room and pillar continuous mining and haulage systems and mine development systems. The BCR Committee supports continuation of the DOE mining technology programs and specifically recommends the following areas of research be accelerated:

Thin seam longwall mining systems.

Continuous mining systems for 24-inch to 48-inch seams.

Semiautomatic roof bolting systems.

Mine waste disposal systems.

The committee also suggested DOE accelerate all of its programs related to longwall mining because longwalls have significant potential for increased productivity as well as increased health and safety.

The potential market for coal in supplying the synthetic fuels industry will quite likely involve technological problems not experienced in serving current utility, industrial and export markets.

The synthetic fuels industry is likely to be composed of large plants requiring a daily delivery of 15,000 to 20,000 tons per day, or an annual tonnage of from 5 million to 7 million tons.

The magnitude of the mine or mines dedicated to synfuel plants, especially if these mines are located in the eastern and midwestern coalfields, raises the question about the adequacy of present mining equipment and techniques, as well as coal transportation, storage, and blending systems.

The synfuels industry will require coal feedstocks with consistent or predictable quality. This means, for example, that there will be a need for the rapid assessment of in-place coal quality and the geophysical techniques to efficiently and accurately delineate coal seams. Significant improvements would be required to provide the mine management with a daily predictive quality and quantity assurance program to meet expected requirements of coal synfuels plants.

DOE's R. & D. programs have been addressing technologies that would be useful for mines serving synfuels plants, but the current level of effort would, at best, provide evolutionary improvements on an extended time scale. Reduced funding, as proposed in the 1981 budget would stretch out programs and make them inadequate to meet expected needs.

The mining technology program that is now the assigned responsibility of the DOE provides an important opportunity to contribute to improved coal mine safety and productivity. For example, the principal managers from the Federal coal mining programs and industry executives met recently with the Joint Development Committee of the United Mine Workers of America (UMWA) and the Bituminous Coal Operators' Association (BCOA) to discuss coal mining health, safety, and productivity problems. The Joint UMWA-Industry Committee, which was established by the Bituminous Coal Wage Agreement of 1978, is chartered specifically to improve labor-management relations by recommending educational programs and policies to resolve differences in work rules and practices, and to advance solutions for improved productivity in the mines.

The dialog that occurred at this meeting between the UMWA representatives, coal producers and research managers, demonstrated that all the parties involved are aware that coordinated and cooperative actions are necessary to resolve mining productivity and safety problems now at hand and those expected as the coal industry expands unless specific actions are taken now to find solutions.

Mr. Chairman, particularly for these five reasons, we believe that the proposed reductions in the DOE's coal mining program are inconsistent with the Nation's need to rely on increased use of coal and with the administration's emphasis on this objective. We urge the committee to review this matter closely and to restore the funding at least to 1980 levels.

That concludes my formal statement. Dr. Yancik and I will be pleased to try to answer any questions you may have.

[The prepared statement of Mr. Bagge follows:]

Statement of

Carl E. Bagge
President
National Coal Association

before the

Committee on Energy and Natural Resources
Subcommittee on Research and Development

U. S. Senate
Washington, D. C.

April 1, 1980

Statement of
Carl E. Bagge
Before the Subcommittee on
Research and Development
Senate Committee on
Energy and Natural Resources

Statement on the Department of Energy
Fiscal Year 1981 Coal Technology Budget

April 1, 1980

Mr. Chairman and Members of the Subcommittee:

My name is Carl E. Bagge. I am president of the National Coal Association which represents coal producers, equipment manufacturers, suppliers, consultants, coal sellers and other service organizations providing technical and financial services to the coal industry.

Accompanying me is Joseph J. Yancik, vice president of research for NCA. Dr. Yancik is also vice chairman of the board for Bituminous Coal Research Inc. (BCR), which is the research affiliate of the NCA. BCR has been actively engaged in coal technology R&D since 1934, and through the years has made many contributions to the scientific knowledge and technologies for mining coal efficiently and safely and the means for the environmentally safe use of coal. Since the early 1960s, BCR has been an active participant in federal programs, developing better coal mining methods and improved ways to burn coal cleanly or to convert coal to clean synthetic fuels.

Briefly, in my statement, I cover four points:

- First, I discuss the need for additional research on health and environmental effects of coal.
- Secondly, I comment on the adequacy of the overall DoE budget for coal R&D.

- Thirdly, I explain our reasons why we believe there are inadequate funds for direct combustion of coal.
- Finally, I comment on and recommend reversal of the planned reduction in federal funding for coal mining R&D.

I. Health and Environmental Effects of Coal Production and Use

While your subcommittee may not be directly involved, we are certain your attention has been called to recent expressions of concern about health and environmental effects of increased coal use. For example, increased media and public attention has been focused on concerns about "acid rain" and a potential buildup of carbon dioxide in the atmosphere due to the combustion of fossil fuels. Much has been written about these subjects. We urge the subcommittee not to lose sight of the fact that the more knowledgeable and objective writers are coming to the conclusion that not enough is known to determine whether the concerns are, in fact, real problems.

The scale of research that is needed to determine whether there are problems far exceeds the resources of industry and there is the added problem that industry research findings on issues such as these are often regarded skeptically.

For these reasons, there is a strong need for government research funding on issues involved in health and environmental effects of increased coal use. We would urge you to seek your colleague's support for increased federal funding for research on these issues.

The coal industry has also increased its research efforts. Specifically, the NCA is funding a project at

Bituminous Coal Research Inc. (BCR) which provides a continuing review of factual information and research findings on such issues as acid rain and CO_2. We believe the results of these projects will be useful contributions to the dialogue on health and environmental issues.

Also, NCA and BCR are following closely the work of the Electric Power Research Institute (EPRI) which has a major research effort focused on health and environmental effects of coal use.

II. DoE's FY 1981 Budget Request for Coal-Related R&D

We are pleased that the President's 1981 budget request for the Department of Energy shows a substantially increased commitment for coal-related research and development. Coal R&D has long been neglected in the federal government's R&D priorities and we, therefore, regard the request for a 39% increase in funding over 1980 as a favorable signal from the Administration.

We would note, however, that a large increase in funding is due principally to the fact that promising technologies being supported by the government have moved to the point where construction of demonstration plants is now necessary. Thus, while the overall level of the request is promising, there are particular program areas where funding is inadequate.

I now turn to the last two points which are of particular concern to us.

III. Inadequate Funding for Direct Combustion of Coal

Our review of the DoE budget indicates that there is a significant decrease in DoE's commitment to the demonstration of technologies which permit clean burning of coal. Specifically, we would note the apparent termination of fluidized bed combustion boiler demonstrations for major industrial plants and the deemphasis of accelerated testing and demonstration of advanced flue gas desulphurization systems.

Both these actions appear contradictory to the Administration's emphasis on the clean burning of coal. Both programs offer near-term potential for increased use of coal in an environmentally sound manner. These technologies, when available, could permit a substantial reduction in the nation's current dependence on oil and natural gas for electric power generation and process heating uses.

We urge the committee to review these reductions carefully and to provide sufficient funds in DoE's 1981 authorizations.

IV. Reduction in Funding for Coal Mining Technology R&D

The second area of our concern is the proposed reduction from FY 1980 funding levels of $22.3 million in DoE's funding for coal mining technology R&D -- from $68.8 million in FY 1980 to $46.5 million in FY 1981. The budget for DoE would reduce underground mining R&D by $17 million -- from $43 million to $26 million and reduce surface mining R&D by $5 million -- from $13 million to $8 million.

The coal industry has plenty of capacity to produce the coal that is now needed in the U. S. and for exports and can accommodate a substantial increase in demand. However, it should be noted that there will be a continuing need for the development and use of advanced mining technologies as the demand for coal increases, as it is necessary to extract coal from thinner or less accessible coal seams, and in order to meet increasingly restrictive health and environmental requirements related to coal mining. It is particularly important to note this need for advanced mining technologies now since there is normally a very long lead time before newer technologies can be developed, demonstrated and brought into widespread use in the coal mining industry.

Because of these needs, we are greatly concerned about the Administration's proposal to sharply reduce DoE funding for mining technology. DoE has not explained publicly its justification of these cuts. They certainly are not justified by any recent breakthroughs which would provide the basis for reduced R&D.

I would like to make five points which we believe support the need for close scrutiny by your subcommittee of the Administration's proposal and for restoring the proposed funding reductions.

A. Federally-funded Mining Technology Programs Complement Industry R&D Efforts.

Federally-funded mine technology programs are needed to complement the mining R&D efforts supported by private industry. Research and development by the private sector has been increasing steadily. The increasing effort is due in part to the DoE program since many DoE projects involve cost-sharing or in-mine testing -- both of which require mining company involvement and often a substantial cost to the mine operators. BCR is now completing a survey, conducted jointly with the Department of Energy, of coal industry mining R&D programs and expenditures. The results of the survey have not been fully analyzed, but there appear to be several significant findings. For example:

- Companies producing 500,000 tons of coal or more annually spend an average of about 16¢ per ton of coal mined on R&D -- for a total of $80 million in 1978. Those producers mine about 76% of U. S. coal production.
- A majority of the expenditures supported demonstration-type projects which involve equipment or a minor modification of a mining technique.
  - In underground operations, a large part of these efforts were directed toward health and safety objectives.
  - In surface mining operations, the efforts focused on reclamation or environmental objectives.

  For both types of mining the predominant goals appear to be a search for more cost-effective ways to operate in full compliance with regulations under difficult mining conditions.
- R&D expenditures by equipment manufacturers and suppliers were focused on development projects. With about one-half of the 70 largest equipment companies responding to the survey, a total expenditure of $47 million was reported. Few specifics on these R&D expenditures were reported because of the competitive nature of the work, but it appeared that most efforts were directed toward improving existing product lines. Some innovative mining machine projects were mentioned but few details were given.

In summary, the survey confirmed that the primary focus of private sector R&D is on near-term improvements in existing equipment and techniques and on solutions to compliance problems rather than on the development of innovative technologies.

Longer range innovative technology development projects are needed and the industry must look to federally-funded programs to fill this gap -- particularly during the period when industry efforts must be focused on compliance with increasingly stringent health and safety and environmental requirements.

B. Viable Longer-range R&D Efforts are Dependent Upon Federal Funding.

The development of new or significantly improved coal mining system technologies requires a series of steps extending over a lengthy period of time. Prior to 1970, a 10- to 15-year time-span was commonly experienced for the development and introduction of new mining methods or significantly new mining equipment. Since 1970, the time required for a major new mining technology to achieve commercial status is more like 20 to 25 years -- due largely to extensive federal and state health, safety and environmental legislation and regulations imposed on mining operations.

Undertaking such a long-term financial risk by the private sector in the development of innovative mining systems is clearly beyond a reasonable business risk, and most likely far beyond the capacity of the coal industry under present economic conditions.

DoE has recognized the need for a strong federal role in supporting long-term developments in the coal use technology area. Also, DoE has undertaken some very high risk developments of alternative renewable energy fuels. However, the 1981 budget in particular ignores this same responsibility for the coal mining technology.

C. Underfunded Areas in the DoE Mining Technology Program.

Because of its importance to the coal mining industry, the BCR Production Research Committee reviewed the DoE's mining technology program plan and the goals and objectives of major projects in the DoE program. The Production Research Committee is eminently qualified to make this review since it is composed of experienced senior level coal executives who have operating and management responsibilities and are aware of present mining problems. They are also cognizant of future problems that are likely to be encountered when domestic production reaches the level of one to two billion tons annually.

The committee concluded that the DoE program plan is generally sound but underfunded in several critical program areas. Underfunded areas include longwall mining systems, room and pillar continuous mining and haulage systems and mine development systems. The BCR committee supports continuation of the DoE mining technology programs and specifically recommends the following areas of research be accelerated:

- Thin seam longwall mining systems.
- Continuous mining systems for 24 inch to 48 inch seams.
- Semi-continuous tunnel drivage systems for slopes and main haulage ways.
- Semi-automatic roof bolting systems.
- Mine waste disposal systems.

The committee also suggested DoE accelerate all of its programs related to longwall mining because longwalls have significant potential for increased productivity as well as increased health and safety.

D. Special Technology Needs for Mines Serving Synfuels Plants.

The potential market for coal in supplying the synthetic fuels industry will quite likely involve technological problems not experienced in serving current utility, industrial and export markets.

The synthetic fuels industry is likely to be composed of large plants requiring a daily delivery of 15,000 to 20,000 tons per day, or an annual tonnage of from five million to seven million tons.

The magnitude of the mine or mines dedicated to synfuel plants, expecially if these mines are located in the eastern and midwestern coal fields, raises the question about the adequacy of present mining equipment and techniques, as well as coal transportation, storage and blending systems.

The synfuels industry will require coal feedstocks with consistent or predictable quality. This means, for example, that there will be a need for the rapid assessment of in-place coal quality and the geophysical techniques to efficiently and accurately delineate coal seams. Significant improvements would be required to provide the mine management with a daily predictive quality and quantity assurance program to meet expected requirements of coal synfuels plants.

DoE's R&D programs have been addressing technologies that would be useful for mines serving synfuels plants, but the current level of effort would, at best, provide evolutionary improvements on an extended time scale. Reduced funding, as proposed in the 1981 budget would stretch out programs and make them inadequate to meet expected needs.

E. An Opportunity to Contribute to Improved Safety and Productivity.

The mining technology program that is now the assigned responsibility of the DoE provides an important opportunity to contribute to improved coal mine safety and productivity. For example, the principal managers from the federal coal mining programs and industry executives met recently with the Joint Development Committee of the United Mine Workers of America (UMWA) and the Bituminous Coal Operators' Association (BCOA) to discuss coal mining health, safety and productivity problems. The Joint UMWA-Industry Committee, which was established by the Bituminous Coal Wage Agreement of 1978, is chartered specifically to improve labor-management relations by recommending educational programs and policies to resolve differences in work rules and practices, and to advance solutions for improved productivity in the mines.

The dialogue that occurred at this meeting between the UMWA representatives, coal producers and research managers, demonstrated that all the parties involved are aware that coordinated and cooperative actions are necessary to resolve mining productivity and safety problems now at hand and those expected as the coal industry expands unless specific actions are taken now to find solutions.

Considerable emphasis was placed on improvements in coal mining technology. Specifically, the DoE coal mining technology program was viewed as a focal point for the development of the new and improved technology that is needed.

Mr. Chairman, particularly for these five reasons, we believe that the proposed reductions in the DoE's coal mining program are inconsistent with the Nation's need to rely on increased use of coal and with the Administration's emphasis on this objective. We urge the committee to review this matter closely and to restore the funding at least to 1980 levels.

That concludes my formal statement. Dr. Yancik and I will be pleased to try to answer any questions you may have.

Senator **Matsunaga**. Thank you, Mr. Bagge.

Now, as you know, not only the administration but the Congress is determined to balance the budget in fiscal year 1981, which means that we have to provide for increases in the area of mining coal. If we have to do that, then we need to reduce the R. & D. in other areas. Do you have any views on what programs we could cut?

Mr. **Bagge**. I am not really qualified to finger any specific program except to say we think this is the most critically urgent and vital program in the whole array of DOE R. & D. programs.

Senator **Matsunaga**. You speak of new technologies in coal mining. How many years have we been coal mining?

Mr. **Bagge**. We were mining coal here in Jamestown when we founded the settlement, I guess it was in 1607, we have been mining coal in this country.

Senator **Matsunaga**. And you feel we still have new technologies to develop?

Mr. **Bagge**. Absolutely. Today the present so-called continuous miner, continuous only about a third of the time, is at least 30 to 35 years old. This was when we mechanized the mines from hand loading.

Dr. Yancik, who is a mining engineer, will respond to your question.

Dr. **Yancik**. One of the critical aspects of the future of the coal industry is to reduce the time of mining and get off the plateau we are presently on with respect to fatalities and severe injuries. This can only get worse because we will have to go down deeper, mine seams under high pressures, very, very gassy. We will have to experience a whole new set of problems underground and we need the new technologies to mine that coal.

Senator **Matsunaga**. One of the most promising uses of coal, from what little study I have done in this area since becoming a member of the Subcommittee on Research and Development, is in situ coal gasification. What is the view of the National Coal Association on the future of in situ coal gasification? As you probably have noticed, we have cut that program down from $10 million to $5 million.

Mr. **Bagge**. We think that is another tragedy. We have been fighting for not only coal gasification in the conventional sense but in situ as well. We thought a few years ago that it was quite far down the line, and we think it still is.

Senator **Matsunaga**. So you do support that program?

Mr. **Bagge**. Absolutely. That has been cut by $1.2 million as well for 1980. In 1981 it has been cut to $10 million.

Dr. **Yancik**. If I might make a comment, a footnote to what Carl has said, in situ is what we call a revolutionary concept to extract coal without having to put miners underground. It has great promise, but has a lot of problems that have to be resolved before it can become a practical technology to apply. We are just now beginning to learn something about the problems, let alone about developing technology, and know-how in order to begin to apply it. So we are in favor of a research and development program that continues to work on this radical concept.

But in terms of it solving any problems as far as coal extraction or providing coal supplies in the next 50 years or so, it would be extremely optimistic to believe that it could have much impact.

Senator **Matsunaga**. The direct use of coal presents environmental problems which coal gasification would not, as I understand it. I would think that because of the increasing opposition among the general public against further polluting of the air and the environment, we ought to seek uses of our energy resources through processes that will least pollute the environment. And I would think that, if we ought to spend money in the area of research and development, it ought to be in an area such as in situ coal gasification, where the projection of environmental pollution is much less than with the direct use of coal.

Mr. **Bagge**. We can't argue with that, although I would respond by saying that even NEPA says that under the new resource performance standards, with the new plants, the new generation of coal-fired plants, that it is going to be cleaner in the future, when we get the new plants built under the new requirements with the scrubbers. The assumption that somehow the direct use of coal as coal in the new generation of utility plants is going to increase pollution is not sound.

Senator **Matsunaga**. The DOE request for environmental research on the effects of coal has been reduced by 25 percent for fiscal year 1980, but includes a significant increase in carbon dioxide effects research. However, DOE testified that there was only $800,000 in the DOE request for acid rain research. Have you examined the proposal for acid rain research in S. 932, title X, and if so, would you support this recommendation and the level of funding?

Mr. **Bagge**. You are referring to the synfuels legislation?

Senator **Matsunaga**. That is correct.

Mr. **Bagge**. We have. We endorse Senator Moynihan's bill and the administration's proposal to put $10 million into a 10 year study of acid rain. We support that because we think that here again we went through the sulfur dioxide hysteria in this Nation a decade ago and now we have evidence demonstrating that our standards that we set were far too high and we are trying to extricate ourselves from that exercise 10 years ago.

We hope as an industry together with the utility industry that we don't now set standards that can't be met based on concerns before they are demonstrated to be real problems. Therefore, we believe it is essential, and I think the first point in my statement related to the need to allay some of the fears or determine whether these fears are in fact well founded so we could develop a strategy concurrent with the development of our coal resources to deal with these problems if we determine they are in fact problems.

We hope that NEPA won't be setting standards for acid rain, CO_2, or a range of other concerns, until we have the scientific data to deal intelligently and meaningfully with these problems.

Senator **Matsunaga**. Thank you very much, Mr. Bagge and Dr. Yancik.

Our next witness is Mr. Sherwood H. Smith, Jr., president of Carolina Power & Light Co. of Raleigh, N.C., accompanied by Dr.

Clark Gibbs, vice president, Mid South Services, Inc., New Orleans, La.

You may proceed.

STATEMENT OF SHERWOOD H. SMITH, JR., PRESIDENT, CAROLINA POWER & LIGHT CO., RALEIGH, N.C.; ACCOMPANIED BY DR. D. CLARK GIBBS, DIRECTOR, NUCLEAR ACTIVITIES, MIDDLE SOUTH UTILITIES, NEW ORLEANS, LA.

Mr. SMITH. Thank you, Mr. Chairman.

My name is Sherwood Smith. I am president and chief executive officer of Carolina Power & Light Co. C.P. & L. has over 7,600 MWe of installed capacity of which about 30 percent—2,245 MWe—is nuclear. An additional 3,600 MWe of nuclear capacity is under construction and we anticipate placing these units in service over the next 10 years. We have been meeting a portion of our customers' demand for electricity with nuclear power since 1971. In 1979, this portion was almost 36 percent. The balance of the demand was met primarily by coal—60 percent. Carolina Power & Light is committed to nuclear power as a safe, economic, and environmentally acceptable method for generating electricity.

I am pleased to be here today to testify on the Department of Energy's fiscal year 1981 nuclear budget request.

I am testifying here today on behalf of the Edison Electric Institute, of which I am vice chairman of its Policy Committee on Governmental Affairs; and the American Nuclear Energy Council, of which I am chairman of the board. Members of the Edison Electric Institute provide about 78 percent of the Nation's electricity and serve over 99 percent—67 million—of all ultimate customers of the investor-owned sector of the industry. The American Nuclear Energy Council represents more than 100 organizations having an interest in nuclear power, including private, public, and cooperatively owned utilities, manufacturers, architect engineers, and various firms in the nuclear fuel cycle.

I am accompanied by Dr. D. Clark Gibbs, director of nuclear activities of Middle South Utilities. Dr. Gibbs is a member of the EEI Executive Advisory Committee on Nuclear Power. I will be making some general comments regarding the need for nuclear power, especially breeder reactors, and the budget in general. I will then ask Dr. Gibbs to speak specifically to the breeder program and the Clinch River breeder reactor (CRBR) project which, as you know, has received no funding in the fiscal year 1981 budget request.

My prepared testimony is before you, and I trust it will receive your attention and be included in the record. In the interests of your time, I will not read it now, but I would like to emphasize a number of essential matters.

Senator MATSUNAGA. Your prepared statement will be included in the record.

Mr. SMITH. I would like to give a few summary comments, if I may.

Senator MATSUNAGA. Fine.

Mr. SMITH. This past year has been an extraordinarily difficult period for electric utility companies and the nuclear industry, particularly those involved in the generation of electricity by the use of nuclear power. The accident at Three Mile Island was the most serious in the history of the U.S. commercial nuclear industry and has focused critical attention on nuclear power as never before. But even before that accident occurred in March of last year, the commercial nuclear program was showing signs of retreat. Since January 1, 1979, 26 planned nuclear plants totaling almost 23,00 MWe were canceled. Since January 1 of this year, 10 units representing over 11,000 MWe were terminated. This means over 330,000 barrels of oil per day displacement capability was deleted from this Nation's energy planning base in this past quarter alone.

The reasons are many for these cancellations, but in large part they are the result of government policies, both at the State and Federal levels. These include escalating licensing and regulatory uncertainties, antinuclear attitudes on the part of some States, inadequate rate relief, coupled with the high cost of raising new capital, and lack of progress in implementing a waste management program. Load forecast reductions and cost increases have also played major roles.

The Edison Electric Institute estimates that even with a low 4½ percent average annual rate of growth by the year 2000 electricity requirements are expected to be about 2½ times the 2.3 trillion kilowatt hours used last year. It is clear that this expansion of electricity production will have to rely on the greatly enhanced development of both coal and nuclear power. Neither can do the job alone.

In 1979, 70 nuclear powerplants, representing 9.6 percent of the Nation's total installed generating capacity supplied about 12 percent of our total output of electricity. An additional 89 plants are under construction. By 1985 the share of energy produced by nuclear energy should increase to approximately 20 percent as plants under construction are completed.

When the nuclear powerplants currently under construction or on order are completed, these plants together with the plants in operation can provide the energy equivalent of more than 4.5 million barrels of oil per day. In order to achieve these benefits, however, it will be necessary to reaffirm the national policy in support of nuclear power and remove the regulatory uncertainties and delays now being experienced.

If nuclear and coal are the only near-term options for increasing our electric generating capacity, the programs which are covered by the Department of Energy's fiscal year 1981 budget will have an important bearing on the strength of the commercial nuclear program in the near term. This is not the time to cut back on nuclear fission research and development. Instead, there must be an even stronger commitment on this research and development if today's bleak picture is to be changed.

The institute and council do not wish to comment on all the programs which our industry supports. We would, however, like to focus on those areas we consider of prime importance and those portions of the fiscal year 1981 budget which we believe should be upgraded:

First, Congress should provide the authority to DOE to acquire and construct regionally sited away-from-reactor (AFR) spent fuel storage facilities and it should establish a funding mechanism so that DOE can operate its long overdue spent fuels storage program.

Second, the research and development program at the Barnwell Nucear Fuel Plant should be continued and enhanced. We support very strongly the statement made a few moments ago by Mr. Colby on the proposed fiscal year 1981 Barnwell program.

Third. The waste isolation pilot program should be continued.

Fourth, more funding must be provided for the breeder reactor program.

Fifth, the ongoing program for identifying and evaluating this country's total uranium resources ought to be completed on schedule.

Sixth, the gas-cooled reactor programs should also be continued.

It is absolutely essential that Congress provide national leadership and issue a mandate to the Department of Energy to continue the development of nuclear technologies if nuclear power is to be a part of our energy future.

Now, as to reactor spent fuel storage, sometimes called AFR, the recent Department of Energy studies on the need for AFR's has shown that AFR capacity between 170 to 1,140 metric tons heavy metal depending upon assumptions of reracking storage pools at reactors and intrautility transshipment will be required by 1983.

We support the recently announced program of the administration, and the initiatives now in Congress, for the acquisition of facilities for away-from-reactor storage of spent fuel. The AFR storage required by 1983 is essential to avoid nuclear generating capacity shutdowns due to the unavailability of spent fuel storage capacity.

The Federal Government many years ago committed to store spent nuclear fuel and to handle the disposition of the residue of high-level nuclear material—both civilian and military. In reliance on this, utilities have committed billions of dollars in nuclear generating facilities, which have only limited onsite storage facilities. Many of these onsite facilities will soon reach their maximum capacity. Because our company was one of the early leaders in building nuclearpower plants, we are one of the companies that could first be adversely affected by the lack of a governmental AFR facility. During the 1980's, however, a number of presently operating nuclear powerplants—perhaps a dozen—will need to ship their spent fuel to a storage facility away from the reactor site or face plant shutdowns. To assure the continued operation of existing nuclear power reactors and to remove an impediment to licensing of future reactors, a congressional directive to the Department of Energy is needed to establish interim storage facilities by early in the 1980's, with a fixed date and location for at least the first one or two such facilities. The first facilities should employ the proven technology of underwater pool storage.

I should emphasize that the cost of programs for storage of spent fuel are not borne by the taxpayers. The utilities will pay to the Government the cost of providing spent fuel storage. These costs, in turn, are reflected in the cost of providing electricity generated by nuclear power and are ultimately borne by the utilities' customers. The implementation of the Department of Energy's AFR plans will remove one of the uncertainties surrounding nuclear power.

As to the Barnwell program, during the past 3 years programs at Barnwell have produced valuable research results on the nuclear fuel cycle and maintained the option of using the Barnwell facility in the future. During this time, Barnwell has developed what many believe to be the most sophisticated nuclear safeguard system in the world. It is now clear from the recently released results of the recently released results of the International Nuclear Fuel Cycle Evaluation Study that breeder reactors and reprocessing are part of the world's energy future. It would be folly for this Nation to abdicate its technological leadership in this area by not continuing basic research and technical developments in reprocessing. It is inconsistent with a continuation of the breeder reactor program at any level not to develop the reprocessing capability needed to fuel the advanced breeder design. We recommend the addition of approximately $12 million to the Department of Energy authorization for the Barnwell Nuclear fuel Plant to continue research and development activities.

Additionally, and extremely important, Barnwell provides one of only three spent fuel pools available to implement the Department of Energy's program of away-from-reactor spent fuel storage. The Department of Energy should, in order to develop the multiregional sites, promptly purchase or lease Barnwell as one of these sites to provide AFR spent fuel storage. The Department of Energy should also continue the valuable fuel cycle research and development at that facility.

As to the breeder reactor program, George Cunningham, Assistant Secretary for Nuclear Energy at the Department of Energy, testified before a Senate and House committee about the need to conduct the necessary research and development activities to insure that the breeder reactor is a viable option for the supply of future energy requirements. Mr. Cunningham's projection was $356 million. We believe that this funding level, rather than the lower level of $226 million requested by the administration, should be provided in order to preserve the breeder option. Additionally, funding for the fuel cycle research and development supportive of the breeder programs should be restored to at least the fiscal year 1980 level and continued funding of the Clinch River breeder reactor project are essential.

The recent successful initial criticality and operation of the Fast Flux Test Facility (FFTF) Test Reactor should provide increased optimism for the eventual commercialization of the breeder technology in this country, which technology is already in use in Europe. This successful FFTF research program should receive more funding. Clinch River is the logical follow-on to the FFTF and would provide that research reactor with a technological mission which can lead to the eventual deployment of commercial breeded reactors.

As to gas reactor programs, we support the continued development of the high temperature gas cooled reactor (HTGR) which offers the advantage of greater operating efficiencies in the range of perhaps 40 percent, greater flexibility in reactor siting, and may supply many industry requirements.

We also support continued development of the gas cooled fast breeder reactor which, due to its unique design features utilizing technology developed for the HTGR and liquid metal fast breeder programs, offers the potential for a very high breeding ratio, greater fuel production, low capital costs and extremely low development costs.

As to uranium resource assessment, the NURE program does not produce more uranium, but it serves to encourage aggressive private exploration. The future of nuclear fission in this country is tied to the availability and the perceptions of availability of domestic uranium resources. We urge the Congress to restore full funding for completion of the uranium resource assessment program in fiscal year 1981.

As to uranium enrichment, we urge the Congress to continue support of the development of gas centrifuge technology for uranium enrichment. The three Department of Energy gaseous diffusion plants have served the U.S. military and domestic and foreign commercial nuclear power programs well. However, the diffusion plants themselves are highly dependent on large quantities of electric energy. Fifty percent of the cost of present uranium enrichment services is the cost of electricity to run the diffusion plants. A gas centrifuge machine would use a third of the electricity to produce the same work.

Congress should encourage the Department of Energy to complete the gas centrifuge plant on its present schedule to have the initial 2.2 million SWU capacity increment at Portsmouth, Ohio, in operation by 1988.

As to commercial nuclear waste and spent nuclear fuel, as an initial step the industry generally supports the President's recently announced program on nuclear waste management. A step-by-step approach has finally been developed which will result in siting, construction and operation of a repository. The schedule for this approach is, however, unnecessarily relaxed.

During the last 4 years, the timetable for operation of the first geologic repository has slipped a full decade from 1985 to the mid-1990's. Furthermore, we believe that the waste isolation pilot program (WIPP) proposed for termination by the President should be carried out as a military R. & D. program to gain valuable experience in disposing radioactive wastes in salt.

We urge the Congress to authorize the Department of Energy to expedite a program for development of mined geologic repositories that will command the confidence of the American people that radioactive waste disposal is indeed a soluble problem.

I would like to add that we believe Senate bill 2189, the Nuclear Waste Policy Act, provides a program that would help resolve the nuclear waste issue and thereby help alleviate some of the uncertainties about nuclear power caused by the nuclear waste issue. The industry strongly urges Congress to pass Senate bill 2189 in its present form or as an amendment to the fiscal year 1981 Department of Energy authorization bill.

The electric utility industry is making its own major contributions toward research and development of technologies to improve our ability to supply electricity to our customers. The budget for 1980 for research programs of the Electric Power Research Institute is $262 million—an increase of 30 percent from last year. Of that total amount, $69 million will be spent by the nuclear power division on programs involving reactor systems, uranium fuels, nuclear wastes, environmental impacts, and developing technologies. Furthermore, to improve the safety of nuclear power plants, through improved safety analysis, plant design, operating procedures, and personnel training, the utility industry has established the Nuclear Safety Analysis Center (NSAC) and the Institute of Nuclear Power Operations (INPO).

The electric utility industry is assuming a fair share of the burden of research and development and improvement of safety in nuclear plants. We do this because of our belief that nuclear energy continues to be an essential ingredient in our energy future. We foresee an even greater role in this country for electricity generated from coal and nuclear power which would help reduce reliance on imported petroleum. An aggressive research and development effort by both the private sector and the Department of Energy must be maintained and expanded.

We commend the leadership of this subcommittee and urge the Congress to pursue relentlessly the advancements in technology that will improve both our near-term and long-term energy picture. Advancements in technology continue to hold the key to our future. We are very much aware of the need of this Congress to seek to reduce Federal spending and to achieve a balanced budget, Mr. Chairman, but we would submit that when one considers the impact of expensive foreign oil upon the rate of inflation in this country that the places to cut our budget are not in energy research and development activities such as I have discussed this morning, because continued successful R. & D. work in the area of nuclear power will lead to the reduction in imported petroleum in this country.

I would now ask Dr. Gibbs to address the breeder programs, and both of us would be pleased to answer any questions that you might have at any time.

Senator **Matsunaga**. Dr. Gibbs may submit his written statement for the record, but inasmuch as, Mr. Smith, you have taken 35 minutes and we have many others, I would appreciate submission of his statement for the record and your submitting yourselves to questions at this time.

[The prepared statements of Mr. Smith and Dr. Gibbs follow:]

Statement of
Sherwood H. Smith, Jr.
President
Carolina Power and Light Company

on behalf of

The Edison Electric Institute

and

The American Nuclear Energy Council

on the

FY 1981 Nuclear Budget

of the U.S. Department of Energy

Before the

Subcommittee on Energy Research and Development

Committee on Energy and Natural Resources

United States Senate

April 1, 1980

My name is Sherwood Smith. I am President and Chief Executive Officer of Carolina Power and Light Company. My Company provides electric service to over 726,000 customers in a 30,000 square mile area made up of parts of North Carolina and South Carolina. CP&L has over 7,600 MWe of installed capacity of which about 30% (2245MWe) is nuclear. An additional 3600 MWe of nuclear capacity is under construction and we anticipate placing these units in service over the next ten years. We have been meeting a portion of our customers demand for electricity with nuclear power since 1971 when our H.B. Robinson unit went into commercial operation. In 1979, this portion was almost 36%. The balance of the demand was met primarily by coal, 60%, and hydro and oil about 4%. Carolina Power and Light is committed to nuclear power as a safe, economic, and environmentally acceptable method for generating electricity.

I am pleased to be here today to testify on the Department of Energy's Fiscal Year 1981 Nuclear Budget request. I am testifying here today on behalf of the Edison Electric Institute, of which I am Vice Chairman of its Policy Committee on Governmental Affairs; and the American Nuclear Energy Council, of which I am Chairman of the Board. Members of the Edison Electric Institute provide about 78 percent of the nation's electricity and serve over 99 percent (67 million) of all ultimate customers of the investor-owned sector of the industry. The American Nuclear Energy

Council represents more than 100 organizations having an interest in nuclear power, including private, public and cooperatively-owned utilities, manufacturers, architect-engineers, and various firms in the nuclear fuel cycle. I am accompanied by Dr. D. Clark Gibbs, Director of Nuclear Activities of Middle South Utilities. Dr. Gibbs is a member of the EEI Executive Advisory Committee on Nuclear Power. I will be making some general comments regarding the need for nuclear power, especially breeder reactors, and the Budget in general. I will then ask Dr. Gibbs to speak specifically on the base breeder program and the Clinch River Breeder Reactor (CRBR) Project which, as you know, has received no funding in the FY81 request.

The past year has been an extraordinarily difficult period for electric utility companies and the nuclear industry. The accident at Three Mile Island was the most serious in the history of the U.S. commercial nuclear industry and has focused critical attention on nuclear power as never before. But even before that accident, the commercial nuclear program was showing signs of retreat. Since January 1, 1979, twenty-six planned nuclear plants totaling almost 23,000 MWe were cancelled. Since January 1st of this year, ten units representing over 11,000 MWe were terminated. This means over 330,000 barrels of oil per day displacement capability was deleted from this nation's energy planning base in this past quarter alone.

The reasons are many, but in large part are the unavoidable result of government policies, both at the state and federal levels. These include escalating licensing and regulatory uncertainties, anti-nuclear attitudes on the part of some states, inadequate rate relief, and lack of progress in implementing a waste management program. Load forecast reductions and cost increases have also played major roles.

Ironically, at the same time that these forces have been buffeting the nuclear option, nuclear power continues to provide the lowest cost, most reliable and environmentally acceptable source of base load electric energy. In 1979, some seventy nuclear power plants, representing 9.6 percent of the nation's total installed generating capacity, supplied approximately 12 percent of our total output of electricity. An additional eighty-nine nuclear plants are under construction with eleven on order. By 1985, the share of electricity produced by nuclear energy will increase to approximately 20 percent as plants under construction are completed. The reliance on nuclear energy is even more pronounced in certain regions of the country. When the nuclear power plants currently under construction or on order are completed, these plants, together with the plants in operation, can provide the energy equivalent of more than 4.5 million barrels of oil per day. In order to achieve these benefits, however, it will be necessary to reaffirm the national policy in support of nuclear power and remove the regulatory uncertainties and delays now being experienced.

In view of these factors, the question of which must be answered is whether the nuclear option is to be preserved and strengthened or whether it is to disappear. Our answer is to call for a strong endorsement of the need for increased nuclear generation. This endorsement should not be given at the expense of other energy sources. The nation clearly needs a balanced combination of coal and nuclear generation, a fact recognized in the recent exhaustive report by the National Academy of Sciences Committee on Nuclear Alternative Energy Systems (CONAES) as well as many other thorough, unbiased studies. So too we as a nation must vigorously pursue the energy savings which can be accomplished through conservation. All domestic energy sources must be utilized if we are to reduce our dangerous dependence on foreign fuels.

Clearly, if nuclear and coal are the only near-term options for increasing our electric generating capacity, the programs which are covered by the Department of Energy's FY 1981 budget will have an important bearing on the strength of the commercial nuclear program in the near-term. This is not the time to cut back on nuclear fission research and development. Instead, there must be an even stronger commitment to this research and development if today's bleak picture is to be changed.

The EEI and ANEC do not wish to comment on all the programs which the industry supports. We would, however, like to focus on those areas we consider of prime importance and those portions of the Fiscal Year 1981 budget which we believe should be upgraded. Congress should provide the authority for DOE to acquire and construct regionally-sited away-from-reactor (AFR) spent fuel storage facilities and establish a funding mechanism so that DOE can operate its spent fuel storage programs in a businesslike manner. The research and development program at the Barnwell Nuclear Fuel Plant should be continued and enhanced. We support the statement made before the Subcommittee by Mr. L. James Colby, Jr. of Allied Chemical Corporation and Mr. James A. Buckham of Allied-General Nuclear Services on the Proposed FY 1981 Barnwell Program. More funding must be provided for the breeder reactor program, which offers one of the most promising sources of energy production with domestically available resources in the decades following the 1980's. The most advanced radioactive waste demonstration program - the Waste Isolation Pilot Program - should be continued. The ongoing program for identifying and evaluating this country's total uranium resources ought to be completed on schedule. Additionally, the gas cooled reactor programs should be continued. Once again, we turn to the Congress to provide the national leadership and to issue a mandate to the Department of Energy to continue development of nuclear technologies if they are to be part of our energy future.

Away-From-Reactor (AFR) Spent Fuel Storage

Recent DOE studies on the need for AFR's has shown that AFR capacity between 170-1,140 metric tonnes heavy metal depending upon assumptions of reracking storage pools at reactors and intra-utility transhipment, will be required by 1983. DOE has based these studies on its judgment that full core reserve capability is an important operational flexibility and economic asset; we agree.

We support the Administration's program, and the initiatives in the Congress, for the acquisition of facilities for away-from-reactor (AFR) storage of spent fuel. The AFR storage required by 1983 is essential to avoid nuclear generating capacity shut-downs due to the unavailability of spent fuel storage capacity. As indicated above, the Congress should provide DOE with the authority to acquire the necessary AFR facilities and should establish a funding mechanism so that DOE can operate its spent fuel storage program in a businesslike manner.

The Federal Government many years ago committed to store spent nuclear fuel and to handle the disposition of the residue of high-level nuclear material - both civilian and military. In reliance on this, utilities have committed billions of dollars in nuclear generating facilities, which have only limited on-site storage facilities. Many of these on-site facilities will soon reach their maximum capacity. Because our Company was one of the early leaders in building nuclear power plants, we are one of the companies that could first be adversely affected by the lack of a governmental AFR facility. During the 1980's, however, a number of presently operating nuclear power plants (perhaps a dozen) will need to ship their spent fuel to a storage facility away from the reactor site or face plant shutdowns. To assure the continued operation of existing nuclear power reactors and to remove an impediment to licensing of future reactors, a Congressional directive to the Department of Energy is needed to establish interim storage facilities by the early 1980s, with a fixed date and location for at least the first one or two such facilities. The first facilities should employ the proven technology of underwater pool storage.

I should emphasize that the cost of programs for storage of spent fuel are not borne by the taxpayers. The utilities will pay to the Government the cost of providing spent fuel storage. These costs in turn are reflected in the costs of providing electricity generated by nuclear power and are ultimately borne by the utilities' customers. The implementation of DOE's AFR plans will remove one of the uncertainties surrounding nuclear power.

Barnwell Nuclear Fuel Plant Program

During fiscal years 1978-1980 Congress appropriated funds for research and development programs at the Barnwell

Nuclear Fuel Plant in South Carolina. Direct Congressional support for the Barnwell programs developed following President Carter's April, 1977 decision to indefinitely defer commercial reprocessing, the purpose for which Barnwell was originally designed and built. During the past three years the programs at Barnwell have preserved the nucleus of its unique technical staff, produced valuable research results on the nuclear fuel cycle and maintained the option of using the Barnwell facility in the future. During this time, Barnwell has developed what many believe to be the most sophisticated nuclear safeguard system in the world. This work has provided valuable contributions to the International Nuclear Fuel Cycle Evaluation (INFCE).

It is now clear from the recently released results of the INFCE study that breeder reactors and reprocessing are part of the world's energy future. It would be folly for this nation to abdicate its technological leadership in this area by not continuing basic research and technical developments in reprocessing. It is inconsistent with a continuation of the breeder reactor program at any level not to develop the reprocessing capability needed to fuel the advanced breeder design. We recommend the addition of approximately $12 million to the DOE Authorization for the Barnwell Nuclear Fuel Plant to continue research and development activities.

Additionally, Barnwell provides one of only three spent fuel pools available to implement DOE's program of away-from-reactor (AFR) spent fuel storage. DOE should, in order to develop the needed multi-regional sites, promptly purchase or lease Barnwell as one of these sites to provide AFR spent fuel storage. DOE should also continue the valuable fuel cycle research and development at that facility.

The Breeder Reactor Program

DOE Assistant Secretary for Nuclear Energy, George Cunningham, has testified before a number of Senate and House Committees that it was one of his objectives to conduct the necessary research and development activities to ensure that the breeder reactor is a viable option for the supply of future energy requirements. Secretary Cunningham's recommendation for FY 1981 for the breeder base program was $356 million. We believe that this funding level, rather than the $226 million requested by the Administration, should be provided in order to preserve the breeder option. Additionally, funding for fuel cycle research and development supportive of the breeder programs should be restored to at least the FY 1980 level. We believe that funding of the breeder program at the FY 1980 level and continued funding of the Clinch River Breeder Reactor project are essential.

Congress authorized the Clinch River breeder program in 1972 as a joint Government-industry effort. Over 750 electric utilities, representing all sectors of the utility industry pledged $257 million towards the Clinch River project. This was, and still is, the largest contribution ever made by the utility industry to a single development project.

Early construction of Clinch River will provide the experience with engineering, licensing and operations which is essential to restore U.S. leadership in breeder technology. It represents an up-to-date, technically sound design and has been continually upgraded to reflect the extensive research and development and proof-test programs. Clinch River is the appropriate scale-up from the Fast Flux Test Facility (FFTF) to confirm the materials compatibility, fabrication techniques and fuels behavior while remaining within the levels of extrapolation prudent under current technology.

Continuation of Clinch River is also needed if the breeder option is to be available in any reasonable timeframe. Further delay will in turn delay subsequent demonstration plants. With the lead times inherent in the process, commercial breeders are, on the most optimistic schedule, at least two decades away. When we consider the magnitude of the fuel resource available with the breeder--a sixty fold increase in the uranium utilization efficiency over current reactors with once-through fueling--further delay in the breeder program is clearly not in the national interest.

Nor do non-proliferation concerns justify the delay. Recently, two major studies relating to non-proliferation and the breeder program have emerged. The DOE's Nonproliferation Alternative Systems Assessment Program (NASAP) study concludes that the liquid metal fast breeder reactor does not present proliferation problems which differ in degree or kind from any other breeder system. Moreover, the recently completed International Nuclear Fuel Cycle Evaluation (INFCE) study has concluded that breeder reactors using plutonium could offer substantial economic advantages to many countries and that the breeder reactor design does not pose any greater risk of diversion of material for nuclear weapons than the existing power plants now in use in the United States and in other countries. Deceleration of the U.S. program and our foreign policy initiatives appear to have had little or no effect on foreign programs. The proposed budget, which signals a virtual halt to the U.S. program, is no more likely to slow the pace and direction of foreign programs. To the contrary, it may well force foreign nations to develop their own technology. Any justification for termination of breeder reactor programs based on non-proliferation concerns is simply not valid.

The recent successful initial criticality and operation of the Fast Flux Test Facility (FFTF) test reactor should provide increased optimism for the eventual commercialization of the breeder technology. This successful research program should receive more funding. Clinch River is the logical follow-on to the FFTF and would provide that research reactor with a technological mission which can lead to the eventual deployment of commercial breeder reactors.

Gas Reactor Programs

The high temperature gas cooled reactor (HTGR) offers the advantage of greater operating efficiencies (in the range of 50%), greater flexibility in reactor siting, and application for many industrial process heat requirements. Recently, the United States signed an Umbrella Agreement for Cooperation with the Federal Republic of Germany and Switzerland to share technology development of the HTGR. Development of the HTGR continues to be supported both financially and with managerial experience through the utility supported Gas Cooled Reactor Associates.

We also support continued development of the gas cooled fast breeder reactor which, due to its unique design features utilizing technology developed for the HTGR and liquid metal fast breeder programs, offers the potential for a very high breeding ratio (greater fuel production), low capital costs and extremely low development costs. This program is supported by a group of utilities known as Helium Breeder Associates. We believe the Administration's proposal to terminate this program is short-sighted and support efforts to restore funds for it.

Uranium Resource Assessment

The National Academy of Sciences Committee on Nuclear Alternative Energy Systems (CONAES) in addressing the role of nuclear energy stressed the need for "a more complete assessment of domestic and world uranium resources, and of the rate they can be produced at various costs." The Administration's response is to cut in half DOE's own recommendation as to the required level of funding for the National Uranium Resource Evaluation (NURE) Program, and to extend the completion date for NURE until the late 1980's. This cut in the NURE Program is inconsistent with planning needs for the mining industry to explore, develop and produce our domestic uranium resources. While the NURE Program does not produce more uranium, it does serve to encourage aggressive, private exploration. The future of nuclear fission in this country is tied to the availability and the perceptions of availability of domestic uranium resources. While we believe there are sufficient uranium resources to provide fuel for present and future nuclear reactors, this perceived uncertainty should be resolved. We urge the Congress to restore full funding for completion of the uranium resource assessment program in FY 1981. Additionally, NURE should thoroughly address the question of uranium reserves on public lands or lands which may be designated as Wilderness areas in the future.

Uranium Enrichment

We urge the Congress to continue support of the development of gas centrifuge technology for uranium enrichment. The three DOE gaseous diffusion plants have served the U.S. military and domestic and foreign commercial nuclear power programs well. However, the diffusion plants themselves are highly dependent on large quantities of electric energy. Fifty percent of the cost of present uranium enrichment services is the cost of electricity to run the diffusion plants. A gas centrifuge machine would use only 4 to 5 percent of the electricity used by a diffusion machine to produce the same unit of separative work (SWU). The gas centrifuge program offers obvious benefits both in conservation of energy resources and in reducing the cost to consumers. It is also an important aspect of maintaining our position in the international community as a reliable and competitive supplier of uranium enrichment services.

We encourage the development of the advanced isotope separation technology which may one day provide an even more efficient and less energy dependent form of uranium enrichment. We only caution that research on the advanced isotope separation process should not detract from the efforts to build the gas centrifuge plant on its present schedule to complete the initial 2.2 million SWU capacity increment at Portsmouth, Ohio by 1988.

Commercial Nuclear Waste

As an initial step, the industry generally supports the President's recently announced program on nuclear waste management. A step-by-step approach has finally been developed which will result in siting, construction and operation of a geologic repository. The schedule for this approach is, however, unnecessarily relaxed. During the last four years, the timetable for operation of the first geologic repository has slipped a full decade from 1985 to the mid-1990's. Furthermore, we believe that the Waste Isolation Pilot Program (WIPP) proposed for termination by the President should be carried out as a military R&D program to gain valuable experience in disposing radioactive wastes in salt. Salt is considered one of the principal candidate media for a geologic repository and the most research to date has been conducted in salt. We note with some satisfaction that one of the conclusions of the INFCE study group was that radioactive waste disposal can be carried out without undue risk to man or the environment. We urge the Congress to authorize DOE to expedite a program for development of mined geologic repositories that will command the confidence of the American people that radioactive waste disposal is indeed a soluble problem.

I would like to add that we believe Senate Bill 2189, the Nuclear Waste Policy Act, provides a program that would help resolve the nuclear waste issue and thereby help alleviate some of the uncertainties about nuclear power caused by the nuclear waste issue. The industry encourages Congress to pass S.2189 in its present form or as an amendment to the FY 1981 DOE Authorization Bill.

The electric utility industry is making its own major contributions towards research and development of technologies to improve our ability to supply electricity to our customers. The budget for 1980 for research programs of the Electric Power Research Institute (EPRI) is $262 million -- an increase of 30 percent from last year. Of that total amount, $69 million will be spent by the nuclear power division on programs involving reactor systems, uranium fuels, nuclear wastes, environmental impacts, and developing technologies. Furthermore, to improve the safety of nuclear power plants -- through improved safety analysis, plant design, operating procedures, and personnel training -- the utility industry has established the Nuclear Safety Analysis Center (NSAC) and the Institute of Nuclear Power Operations (INPO). The Nuclear Safety Analysis Center's immediate task is to obtain the best possible understanding of the accident at Three Mile Island and to determine what responses the nuclear utilities should make. The Institute of Nuclear Power Operations has been established to ensure the highest quality of safe operations in nuclear power plants. Headed by retired Admiral Eugene P. Wilkinson, INPO is charged with the task of assuring that all electric utilities meet benchmarks of excellence in nuclear safety.

The electric utility industry is assuming a fair share of the burden of research and development and improvement of safety in nuclear plants. We do this because of our belief that nuclear energy continues to be an essential ingredient in our energy future. It takes very little imagination to foresee an even greater role in this country for electricity generated from coal and nuclear power. For example, electric mass transportation systems and electric cars would certainly put much greater demand on the electric utility industry and at the same time would offer significant benefits to our overall energy picture by reducing reliance on petroleum products. An aggressive research and development effort by both the private sector and the Department of Energy cannot be overemphasized. We commend the leadership of this Subcommittee and urge the Congress to pursue relentlessly the advancements in technology that will improve both our near-term and longterm energy picture. Advancements in technology continues to hold the key to our future.

Statement of

D. Clark Gibbs
Director - Nuclear Activities
Middle South Utilities

on behalf of

The Edison Electric Institute

and

The American Nuclear Energy Council

on the

FY 1981 Nuclear Budget
(Fast Breeder Reactor Technology)
of the U.S. Department of Energy

Before the

Subcommittee on Energy Research and Development

Committee on Energy and Natural Resources
United States Senate

April 1, 1980

This statement on liquid metal fast breeder reactor technology is submitted on behalf of the Edison Electric Institute and the American Nuclear Energy Council.

The Edison Electric Institute is the association of America's investor-owned electric utilities. Its members provide about 78 percent of the nation's electricity serving over 67 million customers. The American Nuclear Energy Council is a trade association representing the nuclear industry and is supported by more than 100 organizations including manufacturers of nuclear steam supply systems, nuclear fuel and equipment suppliers, architect/engineers and public power, rural electric and investor-owned utilities.

During the last several years, panels of witnesses have appeared before the Congress to present industry testimony on the liquid metal fast breeder reactor (LMFBR) base program and the Clinch River Breeder Reactor Plant (CRBRP) Project. The panels have consisted of representatives from the Edison Electric Institute, the American Nuclear Energy Council, the National Rural Electric Cooperative Association, the American Public Power Association, and some of the principal vendors and engineering firms associated with the breeder program. The panels have thoroughly laid out the arguments in favor of a strong breeder base program, including the Clinch River Project. During this three-year period, they have effectively responded to all of the issues raised by the Administration as grounds for its opposition to the Clinch River Project.

The Administration's proposed 1981 budget calls for a forty percent cut in funding for the LMFBR base program and the termination of the Clinch River Breeder Reactor Plant Project altogether. The stated basis for the latest change in the Administration's breeder strategy is that the date when the breeder will be needed can be extended to the year 2020, and consequently there is no need to proceed rapidly with breeder development and demonstration. Thus, the Administration has again ignored the significance of the inter-related national and international energy events of the past year, the significant progress in the breeder R&D programs here and abroad, as well as the results of the extensive analytical and review efforts pertaining to energy trends and options. The Administration has provided in their place proposed actions that appear to be more directed to further undercutting, rather than enhancing, nuclear power as a domestic energy option. This is despite the Administration's frequent announcements to the contrary and the conclusions and other findings of even its own most recently released energy study.

Clearly, this latest proposed breeder strategy also represents a major change from what was proposed to this Congress and to the industry as recently as last year. The proposed budgetary actions also appear to make a mockery of the Administration's own recent position on the critical nature of nuclear power as well as the finding in a recently concluded international study that the LMFBR is the most significant nuclear power system under development in the industrialized world, because it is seen as the best option to alleviate doubts about resource availability and the security of domestic energy supplies. Consistent with this finding, the demonstration of the LMFBR should proceed without delay so that the breeder option will be available when needed to support continuing growth in nuclear power to meet our electrical energy needs. The prompt pursuit of CRBRP makes sense in today's stringent budgetary and inflationary climate. The technical and organizational readiness to proceed with the plant has been repeatedly reviewed and confirmed. The continuing delays have added significantly to the costs and schedules of the project, and to the breeder base program.

On this basis, we firmly believe that the proposed cuts and other negative programmatic actions are ill-conceived and contrary to the President's own stated determination to "not shut the door on nuclear energy," and accept the reality of the fact that "every domestic energy source, including nuclear power, is critical if we are to free our country from its over-dependence on unstable sources of high-priced foreign oil." Therefore, we strongly urge the Congress to restore full funding for both the LMFBR base program and the CRBRP Project.

The recent turmoil in the Middle East and other international events dramatically illustrate the precarious nature of our continuing dependence on foreign oil to meet our future energy needs. Moreover, several recent realistic reappraisals of the availability of other alternative energy sources to meet these needs confirm the fact that now, more than ever, the United States is critically dependent upon a viable nuclear power program, including a timely breeder demonstration plant program in order to insure a secure energy future. All of these developments underscore the wisdom of the Congress over the past several years in keeping the breeder option alive and call into question more than ever before the soundness of the Administration's repeated attempts to scuttle the CRBRP Project. The most recent proposal to emasculate the LMFBR base program can only be interpreted as a phase-out of the long term viability of nuclear power.

As we approach the end of the twentieth century, there is a consensus that coal and nuclear power must shoulder the burden of meeting our expanding electrical generating supply needs. In fact, study after study has concluded that, in order to meet electricity demands over the next thirty years, the only economic alternative availabile to the United States is the installation and operation of a large number of additional coal-fired and nuclear-powered generating facilities. Conservation measures alone cannot do the job, and the contribution from other alternative energy forms (e.g., solar, biomass, geothermal, fusion) is expected to be marginal at best. Further, in order to insure that the United States will be able to meet its electricity demands beyond that period, these studies have recommended that the development and demonstration of breeder reactor technology should proceed without delay so that the option to deploy breeders can be available early in the next century, if necessary.

In order to have the option to deploy breeders early in the next century, the United States must proceed with the development of the industrial base for such an endeavor as well as with a high priority effort to construct and operate a demonstration plant utilizing the breeder technology. This position has been supported by a number of recently completed studies, such as that of the National Academy of Sciences Committee on Nuclear and Alternative Energy Systems (CONAES), which concluded that the LMFBR offers the best long term technological prospect for insuring an adequate lifetime fuel supply for the nuclear power plants which will be needed in the next century. Deployment of the LMFBR will extend our uranium resources by a factor of about 60 and enable us to productively utilize the tremendous energy potential of the uranium tails presently stockpiled at the various enrichment plants. This energy potential is roughly equal to our total unmined coal resources or at least three times the total OPEC oil resources. The Administration's own analyses are consistent with the view that the LMFBR constitutes our best "insurance policy" for meeting future electrical demand and stretching out existing nuclear fuel supplies. In fact, the

Administration at this time anticipates the develcpment of a commercial breeder reactor by the year 2020. The issue before this Congress is whether the proposed budget matches our country's projected needs and priorities even in an austere budgetary climate. In our view, it does not.

The Administration's opposition to the breeder program and, more specifically the CRBRP Project, was originally predicated upon setting an example on international non-proliferation grounds. Two recent major studies specifically address the relationship between nuclear non-proliferation and the development of breeder reactors. These studies were the Administration's own Non-Proliferation Alternatives Systems Assessment Program (NASAP) study and the International Nuclear Fuel Cycle Evaluation (INFCE) report. These studies vindicate industry, Congress and labor on their persistence in keeping reprocessing and the breeder option viable.

Included among the findings in these studies are:

- Proliferation is primarily a political and not a technical matter.
- There is no single technological "fix" which will insure achievement of non-proliferation goals and objectives.
- Misuse of the fuel cycle is not the easiest nor the most efficient route to nuclear weapons.

- International safeguards are an essential feature of the nuclear power industry.
- For future fuel cycle facilities, including reprocessing, mixed oxide fuel fabrication plants and reactor plants, international safeguards criteria should be applied from the inception of plant design.
- Institutional arrangements will contribute to minimizing proliferation risks and to assurance of supply.

The simple fact of the matter is that all other major industrialized nations (i.e., France, Japan, the United Kingdom, West Germany, and the USSR) were moving ahead with their liquid metal fast breeder development programs while INFCE was pending. The Administration's deferral of the U.S. liquid metal fast breeder program, ostensibly to await the outcome of INFCE, has had little or no adverse effect on these foreign programs.

As recently reported in the two attachments to this testimony, breeder reactors will be a key to the energy future of all industiralized nations.

While the Administration's positions on the breeder progam have been discouraging, we are all proud of the important progress which has been made during the past year. The Project Management Corporation Annual Report summarizes the accomplishments which have occurred on the CRBRP Project in the past year relating to the fabrication and testing of major system components and design completion. The recent successful initial criticality of the Fast Flux Test Facility (FFTF) and other important component and system test results at Hanford, Idaho, Oak Ridge, Argonne and the Liquid Metal Engineering Center have also been encouraging.

Despite the important progress that has been made, it is becoming more and more apparent that these foreign breeder programs are now outstripping the U.S. program. Heretofore, we have taken some comfort in the fact that the superior breadth and depth of the U.S. base program with its diverse and extensive test facilities could at some point compensate for the ever-increasing foreign lead in the pivotal demonstration plant project area. Further, curtailment of the breeder program could eventually result in an insurmountable foreign lead in the development of nuclear power.

Significantly, by falling behind in the development of breeder technology the U.S. would also run the risk of losing whatever modicum of influence and control it now has over the international exchange of breeder technology. A budget proposal which undercuts our technical leadership in this area, as the Administration's proposal most assuredly does, thus appears to be ill-suited towards achieving the United States' repeatedly expressed international non-proliferation goals.

In any event, the breeder option is the only viable insurance policy which the United States now has to meet its future energy needs. The U.S. simply cannot afford to mortgage its energy future by failing to pay the premiums on this policy when they become due. At this juncture, a fully funded base program is imperative. No less significantly, the program must include a viable demonstration plant project. We believe that the Clinch River Project is the right design, at the right place, and at the right time. The 350 MWe size of the reactor represents a prudent extrapolation from the FFTF which is consistent with our own Light Water Reactor (LWR) experience and sound engineering judgment, as well as being comparable to the intermediate size demonstration plants developed in foreign breeder programs. The advanced heterogeneous core design, the key systems design review, and the steam generators and sodium pumps are among the better examples of how the Clinch River design reflects the most advanced state of the art in LMFBR technology. For example, the heterogeneous core, which provides for more efficient use of fuel and a better breeding ratio, was added to the design in January 1979. Study after study has shown that the CRBRP design is still current and even contains a number of advanced design features not yet incorporated into foreign breeder designs. The assertions concerning the "technological obsolescence" of the CRBRP design which the Administration paraded out in its White Paper on CRBRP during the hearings on the FY '80 budget proposal have not been supported. A May 7, 1979 GAO report concluded that the CRBRP was the logical next step in the orderly development of a major energy technology and recommended continued funding of the Project. Before the Administration unilaterally suspended the licensing proceeding in April 1977, the NRC Staff had determined that the Clinch River site was suitable from the standpoint of protection of public health, safety and the environment.

It must also be remembered that the Clinch River Project does not represent an irrevocable commitment to the deployment of commercial breeder reactors; it represents a necessary step towards acquiring the operating experience and data base upon which intelligent decisions on further scale-ups, and perhaps commercialization, can later be made in a time frame consistent with our national energy needs.

In summary, we find the proposed budget completely inconsistent with the national interest. The need for a vigorous breeder program is clear. Non-proliferation problems must be taken seriously, but the solutions lie in the institutional, and not the technical, arena. A U.S. decision to proceed on a vigorous breeder demonstration program is logically separable from the institutional solutions. More significantly, the Administration's proposal would destroy the breeder program by eliminating more than 6,000 jobs around the country and foreclose the breeder as a viable energy option. A vigorous program must be pursued; it must include the Clinch River Breeder Reactor Plant; and we must not rely on an expensive and risky hope of catching up later. Moreover, the time has now come to go beyond merely keeping the breeder option alive. The United States must re-emphasize its commitment to the development of breeder technology and undertake a high priority effort to construct and operate a demonstration plant utilizing that technology in a timely manner. The schedule for completing the CRBRP must not be permitted to slip any further.

For all these reasons, we strongly urge the Congress to restore all prior budget cuts and, consistent with the level of projected expenditures in prior years, authorize full funding for the LMFBR base program, including the Clinch River Breeder Reactor Project.

66-Nation Group Rebuffs Carter, Backs Breeder Reactors

By Milton R. Benjamin
Washington Post Staff Writer

VIENNA, Feb. 25—A 66-nation, 2-year conference today rebuffed President Carter's appeal to curb international use of fast-breeder nuclear reactors. The conference instead adopted a technical report strongly supporting rapid development of breeder technology.

The report adopted today would appear to vindicate foreign countries that have forged ahead with breeder programs. With several Republican presidential candidates clearly on record as favoring development of an American breeder, the new report could make the advanced reactor an election-year issue.

The study, carried out as part of the International Nuclear Fuel Cycle Evaluation, which opened its final session here today, concludes that fast-breeder reactors would release less radioactivity into the air than existing atomic plants and would also expose the operators of nuclear power plants to smaller radiation doses.

The report cited a number of other ecological and environmental advantages for fast-breeder reactors as well. In the climate of concern over nuclear safety that has existed since the Three Mile Island accident, it seems likely to reopen the debate over the fast breeder reactor program in the United States.

President Carter, in organizing the international body's study in 1977, sought to kill construction of a U.S. demonstration fast-breeder reactor at Clinch River, Tenn., and tried to persuade other countries to slow up their breeder programs as well.

The president argued against the spread of fast breeders—so called because they breed more plutonium fuel than they use—out of concern that a sharp increase in the worldwide availability of plutonium, which can be used to fabricate atomic bombs, would add to the problem of curbing nuclear proliferation.

But France, Britain, the Soviet Union, Japan and other countries have pressed on with their fast-breeder programs, and Carter has been unable to kill the Clinch River project. Backers of the breeder have each year pushed funding to keep Clinch River alive through Congress, voting an additional $172 million for the project in September by tacking a rider on a federal payroll bill.

Among the advantages cited for the fast breeder in the report:

- Radioactive releases. "During the normal operation of a power reactor, there are minor releases of radioactivity into the environment in the form of both gaseous and liquid effluents, there is some evidence to suggest that there may be a difference between the two systems, with the fast reactor appearing to demonstrate a clear advantage."
- Radiation exposure. "Occupational exposure should be lower for fast-breeder reactors than for [existing] reactors. Some European utilities are relying on the future fast breeder to decrease the annual dose per operator to well below the figure for the [existing] stations."
- Thermal pollution. "The thermal efficiency of the fast-breeder reactor is higher than that of the [existing] reactor because the fast breeder operates at higher temperatures; the problems of thermal pollution are therefore reduced."
- Nuclear waste disposal. "More waste would be expected to arise from the [existing] power cycle than from the fast-breeder cycle . . . This decrease would require fewer waste handling requirements and, consequently, less permanent storage capacity."

Even members of the U.S. delegation taking part in the fuel cycle talks here concede that the breeder reactor probably would reduce the number of occupational deaths associated with the nuclear industry, since it largely operates on plutonium and thus would reduce the need for the uranium that fuels existing atomic power plants.

A U.S. official said uranium mining is the primary cause of fatalities in the nuclear energy industry.

U.S. officials decided not to dissent formally from the study's general endorsement of breeders for countries with large electricity requirements. They made it clear, however, that they feel the report is too one-sided.

"The need and prospects for breeders understandably are given considerable attention in the light of their promise and the interest that some nations have in this technology," U.S. Ambassador-at-Large Gerard Smith said in addressing the session today.

"But the breeder is not without its costs, risks, and uncertainties," Smith added. "That report focuses much more on the positive features of the technology."

The United States did express satisfaction — from a nonproliferation viewpoint — that the report states that "breeder development and deployment is not likely to be economically attractive in countries with a small number of nuclear power plants, or just embarking on such a program."

In an earlier development, the conference delegates, in a last-minute compromise, elected Y. Yatabe, Japan's chief delegate to the talks, to be president of the group's final session.

Sir Hermann Bondi of Britain had been tapped informally to be president, but the group of 77 — representing 117 Third World nations — over the weekend objected to selection of a delegate from a nuclear weapons country to chair the gathering.

WALL STREET JOURNAL

February 29, 1980

Atomic Speed

France Pursues Drive To Replace Oil Imports With Nuclear Energy

Power Policies of the West Could Depend on Results Of Paris's Commitment

How Serious Are the Cracks?

By JONATHAN SPIVAK
Staff Reporter of THE WALL STREET JOURNAL

LOYETTES, France—Along the lovely Rhone River here in Southern France—an area known locally as "nuclear valley"—the huge cooling towers of the Bugey Central Nuclear Station drape cottony puffs of white fog around Western Europe's largest nuclear complex.

Bugey's five government-built and government-operated reactors already produce over half of France's nuclear energy and one-tenth of all its electrical power. But in a determined drive to reduce dependence on foreign oil, France will soon start installing nuclear plants almost half again as large and put into operation a long-awaited breeder reactor that produces more nuclear fuel than it consumes.

By 1985, if all goes as planned, France will be far and away the Western world's leading nuclear power, producing 55% of the nation's electricity from the atom, more than three times the present proportion. The banks of the Rhone River from the Swiss border to Marseilles will then be dotted with 40 reactors, helping France surpass the combined nuclear-power production of Japan and West Germany, its closest nuclear competitors.

"For us, nuclear power isn't a matter of prestige—it's a necessity," says Maurice Barberger, the man in charge of building France's pioneering but controversial fast-breeder reactor, the Super Phoenix. On a recent nationwide radio broadcast, President Valery Giscard d'Estaing boasted that the French nuclear program "places us in a position of great security" in energy supplies.

$5 Billion a Year

France's all-out nuclear commitment, currently costing $5 billion a year, makes it a fascinating economic and technological proving ground for nuclear energy. The results could not only be critical to France but also determine energy policy throughout the Western industrial world.

Set in motion chiefly as a matter of national prestige more than two decades ago, France's nuclear-power program is the heart of a government drive to achieve faster industrialization and rising consumer living standards. Official plans for a 5% to 6% annual increase in electricity consumption and a real decline in electricity prices depend entirely on nuclear power.

Despite recent discovery of a flaw in the construction of reactor vessels—the program's first potentially serious safety problem—the French nuclear-power effort is also providing support for wavering nuclear plans in other Western European countries. The political pendulum in Europe seems to be swinging back toward nuclear power after a series of setbacks over the past two years.

Popular referendums had blocked operation of an Austrian nuclear plant and tied tight safety requirements to the Swiss nuclear program. The German program was bogged down in arguments over reactor safety and waste disposal. The British Labor government was hostile to nuclear power. And then the Three Mile Island episode in the U.S. caused the Netherlands and several other European countries to consider abandoning nuclear power altogether.

Plans Reaffirmed

Recently, however, Germany, Spain and Italy have either reaffirmed previous nuclear plans or even accelerated them. The British government has just announced its intention to start construction in 1982 of a series of plants similar to the French ones. And nuclear-power advocates are suddenly more hopeful about the likely results of a March 23 referendum in Sweden to determine whether that country builds six more nuclear plants or phases out the six it already operates.

(In the U.S., the Nuclear Regulatory Commission yesterday ended a yearlong moratorium on new nuclear-plant operations. The agency voted to let the Tennessee Valley Authority start up, with limitations, its Sequoyah Unit No. 1 near Chattanooga. See story on page 4.)

Certainly, precarious world oil supplies and the sharp rise in oil prices have helped to swing European sentiment back toward nuclear power. "Iran made a number of countries realize there isn't any attractive option to energy problems—and perhaps the least unattractive one is nuclear," says William Hannum, deputy director general of the Nuclear Energy Agency, a unit of the Organization for Economic Cooperation and Development in Paris.

But certainly, too, the determination and progress of the French effort have also helped change the European climate for nuclear energy. Almost alone in Western Europe, the French government has steadily pushed aside political, economic and technical obstacles. Within days of the Three Mile Island accident, it confidently confirmed its nuclear construction plans and asserted that safety modifications wouldn't be needed in the French reactors.

Pro-nuclear forces in West Germany now argue that one reason to accelerate the German program is to meet the threat of French industries fueled by cheap nuclear power. Firsthand inspection of the French program helped firm up Prime Minister Margaret Thatcher in committing Britain to an expanded nuclear effort. Even U.S. reactor manufacturers, such as Westinghouse Electric Corp. and General Electric Co., are

Please Turn to Page 18, Column 1

28 THE WALL STREET JOURNAL, Friday, Feb. 29, 1980

Atomic Speed: France Is Pressing Drive to Replace Much of Its Oil Imports With Nuclear Power Plants

Continued From First Page

seeking technical information on the Super Phoenix fast-breeder design, in case it proves commercially competitive.

The magnitude of the French undertaking emerges clearly in a visit to "nuclear valley." Here at Loyettes is the Bugey station, the prototype for all future French nuclear parks. To the south, near Pierrelatte, is Eurodif, a huge uranium-enrichment plant. And Creys-Malville, just to the east, is the site of France's greatest nuclear gamble, the Super Phoenix breeder.

The $2.5 billion Super Phoenix is twice as costly as conventional reactors but is designed to manufacture 10% to 20% more nuclear fuel than it consumes in making electricity. Three years ago, technical uncertainties and safety worries forced the U.S. to abandon its fast-breeder project at Clinch River, S.C., and no Western nation other than France has had a fast-breeder commitment since then.

At the moment, France's breeder project is merely a giant concrete shell towering 222 feet above the Rhone. Below, workmen struggle in the bitter cold to fabricate its stainless-steel reactor parts. By the end of 1982, French atomic officials say, the Super Phoenix will begin paving the way to French nuclear independence by extending the use of scarce nuclear fuel 50-fold.

"The fast breeder will make our uranium reserves equivalent to two to three times Saudi Arabia's oil," says Jean Pellerin, an official of the French Atomic Energy Commission. "We don't believe in exchanging oil dependence for uranium dependence." France not only has sizable uranium resources of its own; it also buys additional supplies from former French colonies in Africa, such as Gabon.

Reaffirming France's faith in the gamble it is taking on nuclear power in general and fast breeders in particular, Electricite de France (EDF), the state-owned utility that owns and operates all the nuclear plants, earlier this week announced it had decided to build two more fast-breeder reactors at a cost of almost $4 billion. Construction would start by 1985.

France's nuclear pride and confidence can be easily observed at all the nuclear-valley installations. "There's no way radiation could escape the three barriers around Bugey," declares Pierre Carber, the plant's assistant chief. "The problem is that people don't know what to think—they have been given too much information."

Like most French technological undertakings, the nuclear effort is strongly characterized by aggressive nationalism. It is premised on a grand strategy of complete nuclear self-sufficiency—and has involved the development of uranium mining and facilities for fuel enrichment, reactor manufacturing, fuel reprocessing and nuclear-waste disposal. The entire program takes a major share of the government's civilian construction spending. "All for the grandeur of France," complains Louis Puiseux, a well-known nuclear critic and former EDF employe.

From a technical point of view, the French program receives praise even from its critics. Most of its achievements are commonly attributed to the industry's monolithic organization. As the sole national utility, EDF can order just one type of nuclear plant from a single manufacturer, Framatome, which itself is partly owned by the government. This permits rigid standardization, economies of scale, and rapid construction and installation. "The managers of EDF resist the engineer's temptations to be perfectionists," says Jacques Faure, an EDF official.

While environmental opposition to nuclear power is probably as strong in France as elsewhere in Europe – most polls show a 40-40 division, with the remaining 20% undecided – it has had little political effect. France's highly centralized government structure leaves important nuclear decisions securely in the hands of national officials, who can readily ignore local sentiment. (Even so, several weeks ago, while reaffirming French nuclear-power goals, President Giscard also announced a reduction in electricity rates for residents near nuclear plants – an obvious move to minimize any local opposition.)

There are few legal restraints on the government's nuclear program. Environmental-impact statements began only in 1977 and are far less detailed and burdensome than those in the U.S. France is also the only major Western nation without a nuclear-safety law or an independent nuclear-safety agency.

What legal attacks have been made on the nuclear program have generally failed. Challenges brought on ground of fundamental policy are rejected by the French courts, which consider these matters the province of the executive branch. Thus, legal action is possible only on narrow procedural grounds, and EDF scrupulously guards against such vulnerability. "If the system were the same as the U.S.," complains Philippe Gailliard, a leading anti-nuclear attorney, "probably one-third of the reactors would be shut down." He adds that weakness of the French consumer-protection movement and lack of money also contribute to the difficulties of anti-nuclear efforts.

Perhaps the strongest reason for the unchallenged progress of the French nuclear program is the lack of an effective political opposition. The program enjoys near-unanimous support from the parliamentary parties; even the Communist Party is a strong nuclear advocate on nationalistic grounds. Nuclear-power budgets are routinely approved, and there hasn't been any parliamentary debate on the matter for years.

Besides national security and national prestige, economic realities have provided support for nuclear power, politicians agree: The program has spurred the modernization of an important segment of French industry, stimulated development of government science and engineering, and furnished jobs for about 100,000 workers.

Fragmented and doctrinaire, French environmentalists have failed to win representation in parliament and have abandoned efforts to mount public anti-nuclear protests out of fear that the demonstrations would be taken over by violence-prone radicals.

Recently, however, a major safety problem appears to be stimulating significant public concern. Late last year the Confederation Francaise Democratique du Travail, an umbrella union group that includes the atomic workers' union, revealed the existence of tiny fissures in the steel layers of two nuclear reactors about to be put into operation.

As a result, the Ministry of Industry called a delay of several weeks in the start of the two new plants so as to develop testing equipment for determining whether the cracks are enlarging. Now the go-ahead has been given, but EDF will be required to observe costly 17-week shutdowns at other operating nuclear plants to check their safety.

French atomic officials still remain firmly convinced that the cracks are only a minor technical flaw that poses no serious operating problem. The officials say the program will go forward as planned after careful study. Nonetheless, crows one anti-nuclear scientist, "we demolished the myth of EDF's infallibility."

Senator **Matsunaga**. Mr. Smith, as you know, while you propose primarily nuclear and coal power, one of the real problems with nuclear power is the continued objection of the public. We are seeing demonstrations throughout the country against not only the construction of new nuclear powerplants, but even the continuance of existing powerplants. How do you propose to counteract this type of reaction?

Mr. **Smith**. Mr. Chairman, I first have to say that I think the public concern imposed upon our industry and our Government is a very great burden in terms of communication and providing information that is factual and accurate which the public can come to an informed, intelligent decision with. The very vocal outspoken opponents of nuclear power, I believe, are very much in the minority in this country today, even though if one measured their effectiveness by the decibels that are associated with their protest, one might not immediately come to that conclusion. But the recent Harris Survey shows that the American people, by a very substantial majority, favor the continued development and utilization of nuclear power.

There is no way in this country to generate electricity or to conduct any other similar industrial activity without some element of risk and danger. But when you measure the safety record of the nuclear power industry since its inception in this country, it would stand up very, very favorably to any other activity, so I think the answer to the question is more effort on public education with accurate information, and I think the public will continue to support the greater use of nuclear power.

Senator **Matsunaga**. It is a matter of education, you say. And you say it represents a small minority. But from my observation in talking to people, wherever I go I find the opposite to be true; although those who voice the opposition might be a small number, they do represent, to a large extent, the view of most of the people I have talked with. And, of course it is a matter of eduction if, as you say, nuclear power generation is safer than any other form, and you may be right insofar as the production of power goes. It was not until Three Mile Island it was revealed that perhaps the men who operate these plants need more training.

I am much more concerned about the disposal of the waste matter, and it is, I think, this aspect more than the operation of the plants that the public is concerned about. That is the area in which I feel we need considerable research. Until such time as we have found the answer to neutralizing nuclear waste or proper disposal of nuclear waste, until such time as it can be stored without any harm to human life or any other living being, I can fully appreciate and sympathize with people who oppose the construction of additional nuclear powerplants.

I am not for shutting down what we have today, but until such time as we have the answer to nuclear waste, I do not think we ought to proceed. I do not mean to say that we ought to stop research and development in the areas of nuclear fission and nuclear waste; but as one who is vested with the responsibility of making laws to protect the people, these questions are difficult ones to face.

Mr. **Smith**. Yes, indeed they are, Mr. Chairman. I think you said very clearly and eloquently why in this country we must go forward with such things as reprocessing, which, as illustrated in Mr. Colby's testimony, is an important part of the answer of how to handle the waste, because the high-level waste can be reduced to one-sixth of its initial volume through reprocessing.

As we have urged here, there must be continued R. & D. work, such as the WIPP project. We have urged that the Government proceed with the WIPP project because even if we had never built a commercial powerplant in this country you would still have essentially the same problem to handle because approximately 97 percent of the nuclearwaste problems come from our military program, and we must move ahead and handle these. I think it is essential that we do.

But slowing down the civilian nuclear program and depriving our citizens of lower cost electricity is not the way in which we would handle our waste program. We must go ahead with R. & D., as we see it, very much for the reasons that you stated in your views.

Senator **Matsunaga**. Dr. Gibbs, the statement is frequently made, as we have heard here this morning, that coal and nuclear are our only sources for baseload electricity generation. I understand your utility is one of the participants in OTEC plants in the Gulf of Mexico. What is your view of OTEC's promise, and what is your view of the bills which I introduced relative to the development of OTEC?

Dr. **Gibbs**. Mr. Chairman, that is not my field of expertise. I am not particularly familiar with the technology.

I endorse any form of alternative energy system that has merit. It is my understanding at this stage that the economic questions with respect to many of these alternatives, including OTEC, have not brought that type of technology to the surface yet as one which would be viable.

Senator **Matsunaga**. Are you involved in any alternative sources of energy research and development?

Dr. **Gibbs**. I am the director of nuclear activities for Mid South Services, sir, and my expertise and interest is primarily confined to that.

Senator **Matsunaga**. Do you see any early resolution of the problems of nuclear waste? What is your view of the prospects for fusion energy?

Dr. **Gibbs**. The nuclear waste problem, I think, is primarily an institutional one. It is my understanding that most of the technical questions with respect to disposal of radioactive waste have been fairly adequately resolved. I don't see a connection between nuclear waste disposal and fusion.

Senator **Matsunaga**. You do not see the connection?

Dr. **Gibbs**. Well, except that there is not going to be as much waste coming from fusion. There would be some; certainly not as much.

Senator **Matsunaga**. Well, it would resolve a substantial portion of the objections to nuclear powerplants, would it not?

Dr. **Gibbs**. I think that the magnitude of that problem has been greatly overstated.

Senator **Matsunaga**. Other scientists have said otherwise.

Dr. **Gibbs**. I am aware of that, sir.

Senator **Matsunaga**. Dr. Gibbs, would you explain briefly the rationale for the industry's belief that the Clinch River project should be continued?

Dr. **Gibbs**. Very briefly, sir, the breeder is really our only long-term energy source which has been demonstrated on any reasonable scale, either at home or abroad. It affords us the opportunity to supply this Nation's energy needs essentially indefinitely into the future. The Clinch River Plant is an intermediate milestone which we must go through in a path from where we are today to where we need to be, in order to commercialize this concept.

We had substantial evidence to convince us that the design is the best that we can do in this country; that alternatives to developing our own breeder, such as procuring one from the French or some other European source, are not viable; that if we are to reduce substantially our funding for breeder programs in this country this year by virtue of an attempt to balance the budget, that many of the very highly skilled technical people, which we have very carefully built up through the years, will be lost to the program in all probability forever; and that our overall breeder effort in this country will again experience one more wave which has been largely the cause of our rather poor performance since we initially set off in development of the breeder in the late 1940's. So, in that context, we feel that the Clinch River Plant should be completed.

Senator **Matsunaga**. Thank you, Dr. Gibbs, and thank you, Mr. Smith. I wish we had more time. I could ask you further questions. If we find the need for it, we will submit questions to you in writing, and you may submit your responses for the record in writing.

I deeply regret that we have so many witnesses and so little time.

Mr. **Smith**. Thank you, Mr. Chairman.

If I could just add, the Electric Power Research Institute, which is funded by the public and private utilities, does devote a significant amount of its activities toward alternative energy sources, so all of the utilities are involved.

Senator **Matsunaga**. The subcommittee will stand in recess for just a minute.

[Recess.]

Senator **Matsunaga**. The subcommittee will please come to order.

Our next witness is Dr. L. R. Lawrence, Jr., director of Technical Development, Mechanical Technology Inc., Latham, N.Y.

Dr. Lawrence.

STATEMENT OF DR. L. R. LAWRENCE, JR., DIRECTOR, TECHNICAL DEVELOPMENT, MECHANICAL TECHNOLOGY, INC., LATHAM, N.Y.

Dr. **Lawrence**. Thank you, Mr. Chairman. I would like to voice a brief apology for Dr. Stern, our board chairman, who hoped to be here today. He has a critical illness of a member of his family, and I am appearing in his place.

Senator **Matsunaga**. I am sorry to hear that. I hope it is not too serious.

Dr. **Lawrence**. Time will tell, unfortunately.

I am Bob Lawrence, the director for technical development of Mechanical Technology, Inc. I will present a much abbreviated version of my written testimony.

Senator **Matsunaga**. Your written statement will appear in the record.

Dr. **Lawrence**. MTI is a high-technology organization dedicated to evolving products which are in the national interest, from our strong technology core. We are the epitome of the small, aggressive company responsible for a large part of the industrial innovation which occurs in this Nation, and we have been successful in commercializing our innovations, as may be seen by our corporate 40 percent growth rate and our revenue mix of 50 percent products sales, and 50 percent R. & D. Approximately 25 percent of our business is with the Federal Government and the rest is associated with the private sector.

I am before you today to discuss the issues of the automotive Stirling engine program, industrial conservation, heat pumps, and energy productivity technologies, in general.

The key issues facing the Nation this year are the combined issues of inflation and energy. The rapidly rising costs of primary energy and the lack of a strong program to substantially increase end-use conversion efficiencies are certainly contributors to this situation. Therefore, Mr. Chairman, we are suggesting that Federal expenditures to increase productivity, to increase energy conversion efficiency, and to increase the availability of energy-efficient products and services be looked upon favorably and given priority over expenditures which simply increase the supply of money, realizing that there may be a compelling social need in many cases for allocations which simply increase money supply.

Summarizing an article of Mr. Henry Reuss in the Los Angeles Times, his conclusion is that Government and industry must now discontinue their adversary relationship and work together fostering technological innovations for productivity to place our Nation back on its feet and give us a future standard of living at least equal to that of the present.

I would like to turn briefly to my first two exhibits, which are in the testimony, and explain them briefly to you.

The first one, exhibit 1, which appears directly after page 2 of the written testimony is a very simple graph generated as part of the Oak Ridge National Laboratory Study. In this graph we see two curves. The lower curve shows the savings from programs such as standards, weatherization, the kinds of programs which are urgently needed, which are going into place but are not technological in nature. They are the tightening up, quick fix type of things. They have a large and quick effect, as we can see. However, as they are not technological in nature they provide no basis for further technological advancement and, therefore, you get a flat profile, so that when these things are fully implemented you have realized all of your potential savings.

The upper curve which you see, is the savings resulting from technological innovation. In this case it takes longer for the initial savings to occur because development programs are necessary. However, as the technological innovations go into place you see a continually expanding line because it provides the basis for further advancement.

The Stirling engine automobile provides the basis for improving Stirling engine automobiles. A gas-fired heat pump provides the basis for an improved gas-fired heat pump.

Now, we see again from a Department of Energy study that investment in items requiring energy has increased now to 1979 to that part of our gross national product equaling over $500 billion a year. Of this investment approximately two-thirds is in durables, automobiles, refrigerators, things of that sort, which completely turn over virtually every 20 years. So, in other words, for instance in the automotive fleet, that is almost completely changed out every 10 years. If we look at things like industrial furnaces, refrigerators, home furnaces, these things have about a 20 year life cycle. This means that across our energy-using sectors successful technological innovation has the potential for complete innovation within 20 years.

If we briefly look at the submission in the DOE conservation program for technological innovation, in 81 percent of the energy end-use sectors, we find out that this total is less than 2 percent of the total Department of Energy budget. As a matter of fact, it is very close in total dollars to the amount which is submitted within the conservation budget for something called Energy Impact Assistance, which I am sorry to say, sir, I find a difficult time plotting on this curve here.

Let's go further and look at our major energy end-use sectors and the kinds of improvements which are possible, and the kinds of national benefits which might occur.

First of all, the automotive Stirling engine development program. American automobiles consume an amount of fuel equal to 26 percent of our annual petroleum use. This fuel is consumed in internal combustion engines which power the automobiles at efficiencies of nominally 15 percent. The remaining 85 percent of the fuel energy is released to the atmosphere as waste heat, that is, thermal pollution. In 1975, ERDA—now DOE, NASA, the Congress and the private sector jointly recognized the need for revolutionary automotive powerplants which would be able to utilize a variety of fuels at high efficiency without polluting the environment. An option chosen for accelerated development was the Stirling engine, a technology then in prototype form in Europe.

The automotive Stirling engine program was submitted at $18.5 million. This program consists of one large engine development contract and a small technology effort. The engine development program, managed by MTI, is a goals-oriented technical development program designed to meet the requirements of the Automotive Propulsion Research and Development Act, and show significant progress in automotive Stirling engine technology by 1984. The development program technical team consists of Mechanical Technology Inc., United Stirling of Sweden, American Motors General Corp., and Ricardo Consulting Engineers of England. The primary program goal is to develop an automotive engine which, when tested in a vehicle by EPA, shows at least 30 percent better miles per gallon than the identical vehicle powered by a 1984-vintage internal combustion engine. The technical approach is to achieve this by two engine generations—MOD I and MOD II. Baseline performance is being demonstrated with a USS-developed P-40 engine, a nonautomotive 50 horse power Stirling engine, prototypes of which have been installed in an Opel and in a Spirit.

The first thing we did was hand-build in the laboratory prototypes and replaced one for one these engines. One was an Opel diesel and the other an American Motors Spirit. In both cases we either met or exceeded the miles per gallon these automobiles originally had. We beat the environmental standards for 1985, and we ran these cars interchangeably on a wide variety of fuels, the fuels being diesel, kerosene, gasoline, and alcohol. And we ran it on 150-proof alcohol rather than pure alcohol without any problem at all. This is where the program begins.

The program is now continuing to meet the goals of the Automotive Propulsion Research and Development Act, which we should meet technically by 1984. There are some substantial needs in order to assure that this becomes a commercial reality in our automotive manufacturing base in this country, and these needs are explained in the written testimony.

In order to finish within the allocated time and allow time for questions from the committee, Mr. Chairman, let me briefly say, the heat pump program that was submitted for the Department of Energy represents a technology that utilizes the solar energy present in the atmosphere and pushes this energy from a low temperature energy in the atmosphere to a high temperature inside the house, heating at efficiencies approximately two to three times the kind of efficiency possible from direct conversion.

In the industrial conservation area, the Department of Energy has already displayed that it knows how to act in concert with the private sector and how to accelerate highly beneficial technologies into commercial practice. We are recommending that the add-on which occurred in the House yesterday be also considered on the Senate side. That is a $40 million add-on to this program, which brings it up to less than $100 million, but still less than a half a percent of the total DOE budget. However, the programs are well enough thought out, the benefits to the Nation are substantial, and we would like to support that as well.

Last, Mr. Chairman, there is a program called energy conversion and utilization technologies, which due to an unfortunate change in responsibility was originally started in ERDA in the conservation program, was shifted over to energy technology, and wound up under the fossil energy program, where it received a lower priority than the coal programs, understandably, and has virtually gone away. This year we see DOE again attempting to start this program within conservation at an $11 million figure. When it left it was at $52 million, and the technology base created by this program is essential for the kind of equipment that we hope to evolve to solve the unused energy problems.

I have a brief concluding paragraph, Mr. Chairman.

On the occasion of this testimony, the United States is locked into an economic and technological struggle of exceptional intensity. The battleground is every home, office, automobile, and factory in the United States, and the weapons are the supply, conversion, and end use of energy. An essential need for our security and maintenance of living standard is multifaceted technological innovations for improved energy productivity. The fact is that, to date, we have not been successful in our energy efforts. The future controls us; we don't control it; and as long as we are in that mode, we have not succeeded; and the American way of life and standard of living are substantially at risk. It is up to Americans everywhere, in government and industry, to regroup, dedicate even more of ourselves to this effort, and work together to overcome our energy malady because, very simply, our futures, our children's futures, and their children's futures hang in the balance. Thank you.

[The prepared statement of Dr. Lawrence follows:]

United States Senate
Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development

Hearings on DOE Conservation Program

April 1, 1980

Statement of:

Dr. L. R. Lawrence, Jr.
Director
Technical Development

Mechanical Technology Incorporated
968 ALBANY-SHAKER ROAD • LATHAM, NEW YORK 12110 Phone 518/785-2211

Mr. Chairman and Members of the Committee:

I am Dr. L.R. Lawrence, Jr., the Director for Technical Development of Mechanical Technology Incorporated (MTI). MTI is a high-technology organization dedicated to evolving products which are in the national interest, from our strong technology core. We are the epitome of the small, aggressive company responsible for a large part of the "industrial innovation" which occurs in this nation, and we have been successful in commercializing our innovations as may be seen by our corporate 40% growth rate and our revenue mix of 50% products sales, and 50% R&D. Approximately 25% of our business is with the federal government, and the rest is associated with the private sector.

I am before you today to discuss the issues of the Automotive Stirling Engine (+$10M), Industrial Conservation (+$50M), Heat Pumps (+$3M), and Energy Productivity Technologies (+$14M).

The key issues facing the nation this year are the combined issues of inflation and energy. The rapidly rising costs of primary energy and the lack of a strong program to substantially increase end-use conversion efficiencies are certainly contributors to this situation. Therefore, Mr. Chairman, we are suggesting that federal expenditures to increase productivity, to increase energy conversion efficiency, and to increase the availability of energy-efficient products and services be looked upon favorably and given priority over expenditures which simply increase the supply of money (realizing that there may be a compelling social need in many cases for allocations which simply increase money supply).

Mr. Chairman, this past year has shown dramatically the vulnerability of the American way of life. Gasoline allocations have become standard and, while 50% of our petroleum still must be imported, we see much of that supply newly threatened by a Soviet invasion of Afghanistan, and a simultaneous Soviet military buildup near the borders of oil-producing nations. Our energy crisis has been heightened. Interrelated to these events, we are seeing 18% inflation and growing signs of impending recession. Henry Reuss recently published an analysis in the Los Angeles times, excerpts of which follow:

> No full-scale overhaul of anti-inflation policy is in prospect.
>
> Such an overhaul is urgently needed. The source of our inflation is not overall fiscal and monetary mismanagement alone; therefore inflation cannot be cured solely with monetary and fiscal restraint. Nor is the problem exclusively one of OPEC oil; other nations import more of their oil than we do, but have lower rates of inflation.
>
> Our inflation problem is the result, instead, of a gradual but steady decline in economic performance over the last 15 years in productivity, in manufacturing output and in product design. In sector after sector, we produce insufficient quantities of badly designed products at too high a cost. As a result, we are losing market shares in the world at large as well as at home. The consequence: rising unemployment, inadequate profits and therefore reduced investment in our manufacturing sectors, still worse productivity, a falling dollar and worse inflation.

> Our goal must therefore be to restore the productivity and competitiveness of U.S. industry and other major economic sectors in domestic and world markets. To do this, we must abandon the adversary business-labor-government relationship that now exists, and adopt the cooperative approach that has been tried and proven by several of our major allies and rivals, notably Germany and Japan.
>
> The U.S. government can and should take the lead in transplanting this successful model of cooperative capitalism to our shores.

Simply put, the conclusion of Mr. Reuss is that government and industry must discontinue their adversary relationship, and work together, fostering technological innovation for productivity to place our nation back on its feet and give us a future standard of living at least equal to that of the present.

Mr. Chairman, in the end-use arena, our nation has yet to "bite the bullet" and provide the kind of cooperative government-industry effort needed for us to protect and enhance the American standard of living. Instead, there are growing signs that our standard is decaying, and will continue to decay.

Some possible approaches to alleviating our problems are joint efforts in improved energy productivity. Exhibit 1 is a graph from a study accomplished by the Oak Ridge National Laboratory (Reference 1) and, although the study only addresses the residential sector, we have found the result to have more general applications.

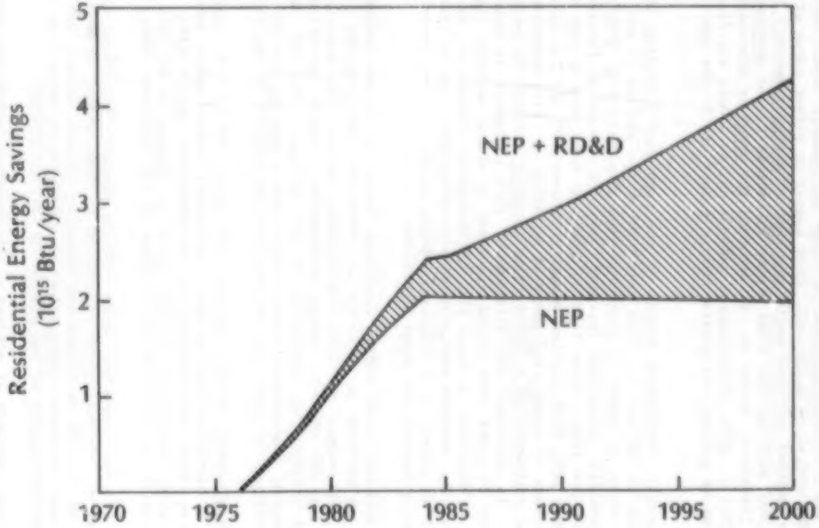
The portion of the exhibit which is labeled NEP refers to initiatives such as regulation, the schools and hospitals program, insulation programs, and regulations forcing thermostats down in winter and up in summer. Regulations are a form of crisis management, and should only be imposed when all else fails, and should be removed when technological successes surpass regulatory goals. Regulations achieve early impact but, when fully implemented, show no additional gains. In addition, regulatory initiatives cause creative engineers to be removed from R&D projects with strong future promise, and applied to "product improvement" crash programs trying to meet federal standards and test procedures with viable equipment. This provides a "quick fix" at the expense of potential long-term solutions. It also creates a large amount of technical "duplication of effort," something which DOD and NASA have long sought to avoid in their successful development programs.

The upper curve in Exhibit 1 shows the effects of RD&D, or technological solutions. The technology for improved efficiency of utilization may be slower in coming, but its impact is to create a technological base which may be further improved and expanded upon, leading to continued utilization efficiency improvements, for continually increasing energy savings. Technological solutions provide needed end-use energy forms from less energy resources. In addition, the resulting new products create employment opportunities, expand exports, and stimulate small businesses, improving overall economic health.

Mr. Chairman, it is distressing to see that the national crisis in energy availability has produced a DOE budget that seemingly reflects panic. If we look at the line items containing technological solutions such as Buildings and Community Systems, Industrial Conservation and Transportation Conservation, they are all submitted below their FY 1980 levels. In contrast, the

EXHIBIT 1

Residential Energy Savings Due to Implementation of NEP Conservation Programs and Development of New Technologies



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"quick-fix" impacts on the American standard of living through items such as the State and Local programs, and "Multi-Sector" programs have been increased, and we see a further increase of $100M for "energy impact assistance," something the effect of which will never appear on either curve of Exhibit 1. It must be pointed out that world supplies of energy resources do not follow a flat curve such as the lower curve in Exhibit 1, but decrease from year to year. Therefore, unless we can get onto the upper or increased savings curve of Exhibit 1, with technological innovation, we simply are digging a hole for ourselves by greater and greater forced reductions in the American standard of living.

An extremely interesting result of the past year's studies (Reference 2) is reflected in Exhibit 2. This curve shows the portion of our Gross National Product which is spent on products which require energy input; i.e., homes, cars, toasters, industrial furnaces, etc., as opposed to furniture, land, carpet, and the like. From 1970 to 1978, we have seen a jump in energy-using investment from $200 billion annually to over $500 billion annually. Exhibit 3 (Reference 2) shows that the vast majority of this expenditure is on durables and equipment, or on those items directly affected by technological innovation. In addition, the lifetime of this equipment is almost universally less than 20 years (the automotive fleet is almost entirely replaced every 10 years!). Therefore, a successful technological innovation, in equipment with substantially improved energy conversion efficiency, can be expected to have a substantial impact in a reasonably short period of time compared to many energy supply options now under discussion.

Having observed these rather startling facts, it is now important to examine energy use patterns in order to see where dedicated programs aimed at technological improvement can have the greatest impact. The industrial sector accounts for 36% of U.S. energy consumption, nearly two-thirds of which is supplied directly or indirectly by oil and gas. The DOE budget addresses technological innovation in this sector with a decrease in 1981, to a level of $58.9 million, or LESS THAN ONE-HALF OF ONE PERCENT OF THE TOTAL DOE BUDGET!

The transportation sector accounts for about 26% of U.S. energy consumption and 53% of petroleum consumption. Successful technological innovation in this sector can result in a substantial and widespread impact within ten years, yet technological innovation in this sector is reduced in the 1981 budget submission to $113M, or LESS THAN ONE PERCENT OF THE TOTAL DOE BUDGET!

Residential and commercial space heating accounts for 19% of our national energy demand. Technological innovation in this sector is addressed within a segment of the DOE Buildings and Community Systems budget labeled Technology and Consumer Products. This effort is submitted at about $22M for FY 1981, or LESS THAN ONE-QUARTER OF ONE PERCENT OF THE DOE BUDGET!

WE HAVE NOW EXMAINED 81 PERCENT OF THE NATIONAL ENERGY USE PATTERN, AND FOUND TECHNOLOGICAL INNOVATION IN THESE AREAS TO BE ADDRESSED WITH LESS THAN TWO PERCENT OF THE TOTAL DOE BUDGET!!

It is incredible to see such items as "Energy Impact Assistance" be increased from $50M to $150M within a budget labeled "Conservation" when, at the same time, solutions involving technological innovation receive budget cuts. Mr. Chairman, it is clear that this trend must be reversed for the good of our

EXHIBIT 2

ENERGY INVESTMENT, 1960-1978

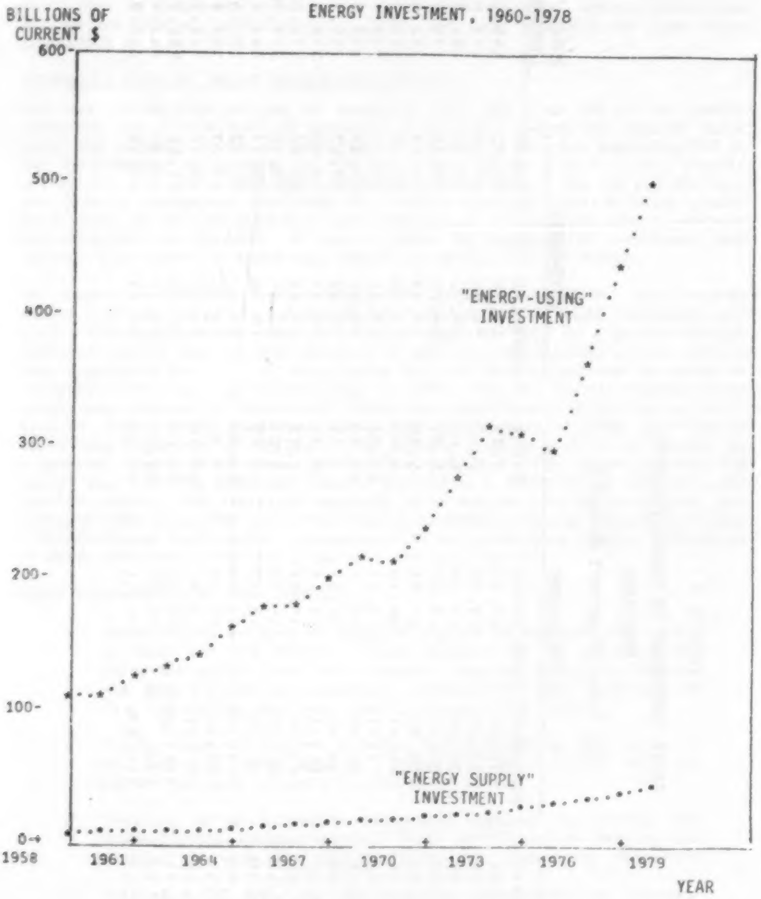

EXHIBIT 3

GROSS INVESTMENT IN TANGIBLE ASSETS,
1960-1978
(billions of current dollars)

	HOUSEHOLDS		*PRODUCERS*			*GOVERNMENT*		*TOTAL GROSS INVESTMENT*
YEAR	*DURABLES*	*STRUCTURES*	*EQUIPMENT*	*STRUCTURES*	*INV Δ*	*DURABLES*	*STRUCTURES*	
1960	43.12	24.45	30.05	18.17	3.77	11.20	15.82	146.60
1961	41.57	24.50	29.25	18.35	2.17	14.00	17.20	147.05
1962	46.72	26.90	32.35	19.45	6.47	14.42	17.95	164.27
1963	51.42	30.02	34.62	19.57	5.97	14.25	19.30	175.17
1964	56.35	30.52	38.80	21.45	5.80	13.87	20.45	187.25
1965	62.77	30.55	45.85	26.10	9.52	13.35	22.07	210.22
1966	67.67	28.05	52.87	29.22	14.32	14.50	24.10	230.75
1967	69.65	27.95	53.30	29.50	10.10	16.32	25.50	232.32
1968	80.00	33.70	58.52	31.57	7.72	16.52	27.67	255.72
1969	85.45	37.00	64.15	35.65	9.37	16.57	28.00	276.20
1970	84.95	35.67	63.67	37.67	3.77	18.02	28.22	272.00
1971	97.10	48.55	65.77	39.32	6.35	16.40	30.20	303.70
1972	111.25	60.95	75.35	42.52	9.42	17.95	30.77	348.22
1973	123.72	64.90	88.15	49.02	17.90	16.47	33.32	393.50
1974	122.00	53.87	97.30	54.45	8.92	15.05	39.07	390.67
1975	132.55	50.40	97.47	53.80	-10.70	19.40	40.47	383.50
1976	157.42	66.77	108.90	57.32	10.05	21.72	38.62	460.82
1977	178.82	90.32	128.37	62.65	21.95	23.32	37.97	543.42
1978	200.30	105.15	146.55	75.55	22.30	23.52	45.52	521.00

SOURCE: NBER DATABASE

nation's future. I don't intend to state that we must instantly shift $5 billion to technological innovation for improved conversion efficiency, but I would like to point out a few key areas where accelerated, ordered growth can produce substantial technological payoffs, and move us toward the upper curve of Exhibit 1.

AUTOMOTIVE STIRLING ENGINE DEVELOPMENT (+$10M)

American automobiles consume an amount of fuel equal to 26% of our annual petroleum use. This fuel is consumed in internal combustion engines which power the automobiles at efficiencies of nominally 15%. The remaining 85% of the fuel energy is released to the atmosphere as waste heat (i.e., thermal pollution). In 1975, ERDA (now DOE), NASA, the Congress and the private sector jointly recognized the need for revolutionary automotive power plants which would be able to utilize a variety of fuels, at high efficiency, without polluting the environment. An option chosen for accelerated development was the Stirling engine, a technology then in prototype form in Europe.

The Automotive Stirling Engine program was submitted at $18.5M. This program consists of one large engine development contract and a small technology effort. The engine development program, managed by MTI, is a goals-oriented technical development program designed to meet the requirements of the Automotive Propulsion Research and Development Act, and show significant progress in automotive Stirling engine technology by 1984. The development program technical team consists of Mechanical Technology Incorporated (MTI), United Stirling of Sweden (USS), American Motors General Corporation (AMG) and Ricardo Consulting Engineers of England. The primary program goal is to develop an automotive engine which, when tested in a vehicle by EPA, shows at least 30% better mpg than the identical vehicle powered by a 1984-vintage internal combustion engine. The technical approach is to achieve this by two engine generations (MOD I and MOD II). Baseline performance is being demonstrated with a USS-developed P-40 engine, a nonautomotive 50 hp Stirling engine, prototypes of which have been installed in an Opel and in a Spirit.

Major achievements to date include:

1. Installation and test of baseline engines in two vehicles, i.e., an Opel and AMC Spirit. These engines met or exceeded the miles-per-gallon found with standard internal combustion engines and demonstrated environmental acceptability with a variety of fuels including gasoline, diesel, kerosene and alcohol.

2. Final design of the MOD I engine and approval by NASA to build and test 7 of these engines. These will be the first Stirling engines designed strictly for automotive use.

3. Creation of an effective management approach to utilize two transatlantic subcontractors. This is critical to keeping the program on schedule and providing for technology transfer.

4. Initiation of materials and component developments to increase practicality of engine design.

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TABLE 1

Miles per gallon:

(EPA measured on unleaded gasoline)

	Opel	
	Diesel	Stirling (3000+ lbs)
Combined:	24.8 mpg	*23.3 mpg

	Spirit	
	Standard V-8	Stirling (3500 lbs)
Urban:	N/A	17
Highway:	N/A	28.7
Combined:	18	20.8

Emissions

gm/mile (EPA measured)

	Opel Diesel	Opel Stirling	Spirit Stirling	1985 Standard
CO	1.6	1.43	3.0	3.4
HC	.32	.12	.12	.41
NOx	1.48	.37	.39	0.4

*Corrected for energy density difference between diesel and unleaded gasoline

5. Transfer of meaningful technology and know-how regarding the P-40 engine specifically and Stirling engines in general to the United States.

6. Development of a reference engine concept which, when coupled with data from the MOD I, will provide the initial design for MOD II.

The MOD I engine will provide approximately 50% of the progress needed toward successful achievement of the program goal of 30% improvement over the internal combustion (IC) engine. Computer predictions indicate a combined drive cycle figure of 27.3 mpg for MOD I compared to the IC Spirit figure of 22.2 with substantially less emissions for the Stirling-powered vehicle. Although the MOD II design has not started yet, a goal in excess of 35 mpg has been established for the engine in a 3000-pound car and appears feasible. The Automotive Stirling engine program is on schedule and on cost and gives clear indications the Title III goals will be met.

Although the Stirling cycle dates from the early 19th century, substantial research in engines based on this cycle has occurred only in the past few decades. This work has been done at the Philips Laboratories in Holland and United Stirling in Malmo, Sweden. Until several years ago, Stirling engines were virtually unknown in the U.S. There is little awareness, presence or appreciation of Stirling engines today in the United States, outside of a relatively small group of energy conservation-oriented scientists and engineers. The application of this technology can be substantially accelerated by expanding the present technology development program as follows (recommendations apply specifically to FY 1981):

1. Education and Training - Engines, course material and faculty training should be provided at the college and vocational school level. No course in Stirling engines is presently offered anywhere in the United States. Making engines and other resources available will result in research and training activities and provide engineers, scientists and technicians with the background necessary to design and maintain Stirling engines for energy-saving applications in all end use areas.

2. Commercialization - Although Stirling engines are increasingly regarded as one of the most promising heat engines for our future needs, they must compete for investment capital with the presently entrenched but less efficient Otto and Diesel cycle engines. Studies addressing market penetration, entry opportunities and cost goals will enhance decision-making in industry in favor of the Stirling engine. These studies must begin now to accommodate the timetable for the National conservation goals rather than at the end of the technology development. This timing is necessary in order to expedite the traditionally slow process of industrial plant turnover and new product introduction.

3. Production and Advanced Technology - The present goals-oriented Stirling technology program should be complemented by a program specifically oriented toward the development of the necessary

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production technology and engine concepts based on advanced technologies such as ceramic components. The Stirling engine embodies several critical components — such as the heater head — which represent both a substantial cost portion of the total engine and a limitation on performance. U.S. vendors and suppliers should be encouraged to apply their skills and expertise to improve the performance and reduce the cost of these key components as a necessary step toward economical mass production of Stirling engines. At the same time, design concepts incorporating other promising materials and manufacturing techniques should be pursued for both engine performance and simplification of design.

Advanced Program

The current program is designed to meet the performance goals of 30% improvement that stem from Title III. The real benefits to the United States will accrue from mass production of automotive Stirling engines at the earliest possible date. This will entail significant risk and expenditure on the part of the engine licensee(s). Two steps are advocated to lessen these risks and improve the chances of implementing this technology on a more timely basis.

The first step is an effort that parallels the present program at a modest rate initially and then provides the stepping stone to a production-oriented engine at the completion of the Title III program in 1984. This program should center around a Production Reference Engine (PRE) as a guide to component development and engine design required to support fabrication to pilot-run quantities of improved engines in the mid 1980s. As contrasted to the present technology program emphasizing performance, this program would emphasize parts reduction, ease of assembly and maintenance, maximum tolerance allowances and other criteria related to low cost of manufacture and ownership. This advanced program is crucial to the present Stirling contract team, which is dedicated to the commercialization of Stirling engines. Approval of this initiative could set the stage for bringing a second team into being and alternative funding is also shown for this situation. The following scope and funding should be set:

Fiscal Year	1981	1982	1983	1984	1985	1986
Program	PRE, Comp & Mfg. Studies	PRE, Comp & Mfg. Studies	Prelim. Design	Hard Design & Fab	Fab & Test	Test & Evaluation
Funding (1 team)	$2M	$4M	$ 5M	$9M	$12M	$8M
Funding (2 teams)	$4M	$8M	$10M	---	----	---

Total funding: $40M (1 team)
Total funding: $62M (2 teams)

The second step is the demonstration of a suitable number of Stirling-powered vehicles in the 1984-86 time frame. This program is an analog to the Congressionally inspired electric and hybrid vehicle program and is intended to achieve essentially the same effect. By demonstrating small fleets of Stirling-powered vehicles, public awareness can be stimulated and the consumer can gage for himself the importance of efficient, clean-burning engines in automobiles. Valuable information on consumer reaction, geographical variations in engine performance and general driveability will be obtained. Multifuel usage would also be included and will generate meaningful data on performance variability related to locally indigenous alternate fuels; i.e., alcohol-based fuels in the corn belt and coal-derived fuels in Appalachia. It is suggested that PL94-413 be amended to incorporate demonstration fleets of advanced Stirling engine-powered automobiles and that the following time table and funding be set:

Fiscal Year	1981	1982	1983	1984	1985	1986	1987	1988
Program Scope, No. of Vehicles	Planning	Planning	Site Selection	400	Field Test	800	Field Test	Evaluation Reports
Funding	$1.5M	$1.5M	$2M	$10M	$4M	$16M	$4M	$2M

Stirling technology is presently a European technology in spite of the fact that it is generally regarded as exceptionally promising, and the United States is one of the few countries that can effectively exploit it in terms of capital formation and application. Wherever employed, the Stirling engine will reduce fuel consumption by a minimum of 30% with the potential of exceeding 50%. The net benefits to be derived from reduction of liquid fuel use, slowing down inflation and beneficial environmental impact are greater for the United States than any other nation. The automobile represents the most difficult, yet the most advantageous application for Stirling technology, and it is appropriate for the Federal Government to fund this high-risk, high-payoff activity.

The benefits of transferring Stirling technology to the U.S. are not limited to reduction of transportation fuel consumption, as significant as this goal may be. Stationary Stirling engines can likewise achieve significant energy conservation and are even more fuel tolerant than automotive Stirling power plants. Stationary Stirling engines can run on any thermal energy source -- including solar, wood residues, geothermal and even municipal solid waste as well as conventional and synthetic gaseous and liquid fuels.

Stationary Stirlings can generate electricity, run heat pumps for building space conditioning, pump water in rural areas and a variety of other applications presently serviced by fossil-powered prime movers. The creation in the United States of an automotive Stirling engine industry would provide a technology and vendor base for the ready application of stationary engines at a lower cost than the narrower commercial markets mentioned above could otherwise create. In effect, the introduction of the automotive Stirling will create a huge capability of component suppliers, fabrication houses, maintenance schools and training institutions that will accelerate the commercialization of smaller but vital product lines such as generator sets, compressors, heat pumps and hydraulic units. The availability of low-cost stationary Stirling engine systems will enable us to utilize marginal energy sources such as wood waste, and renewable sources such as solar to cut foreign oil imports and protect the environment while preserving our standard of living.

HEAT PUMPS (+$3M)

Thanks to Congress, a strong heat pump R&D effort was initiated about two years ago. The emphasis of this effort has been on gas-fired heat pump concepts, with a minor effort aimed at improving electric heat pump efficiency. Although this program has achieved technologically what statements before the House Science and Technology Committee had projected it would, it's funding gets constrained every year. It is presently submitted at $8.5M for 1981, and could easily use an increase of $3M.

Electric Heat Pumps

Electric heat pumps have been in the marketplace for about 30 years. However, the impetus for broad implementation was only reached in the early 1970s as, concurrently, the technology matured, the availability of natural gas dwindled resulting in moratoriums, the rate of new residential construction starts increased, and the price of electricity increased markedly. This produced a market demand which lead to the following shipments of residential units:

HEAT PUMP SHIPMENTS
(000 Units)

1971	1972	1973	1974	1975	1976	1977
67	81	87	97	128	250	493

This rapid market expansion led to projections by the nation's leading market forecast houses of over one million units per year by 1990. In turn, this led heat pump and compressor manufacturers to invest in extensive new production capacity in order to meet the projected market demand, and (in some cases) the construction of additional capacity in an attempt to increase market share. A projection by one leading market analysis house, which they labeled "pessimistic," projected the following unit sales:

PROJECTIONS (AT THE END OF 1977)
HEAT PUMP DELIVERIES
(000 Units)

1977 (Actual)	1980	1985	1990
493	640	780	1001

The blow to electric heat pump manufacturers came in 1978 and this past year (1979). With the perceived increased availability of natural gas and the lifting of moratoriums, deliveries were (000 Units):

1978	1979 (Estimated)
572	510

With the heat pump and compressor manufacturers now generally substantially over-committed in terms of capacity, paying high interest rates on their capital facilities, and in a low-profit margin market, they are generally in a difficult financial position. As a result of this situation, electric heat pump systems, with revolutionary improvements in compressor design and efficiency, are neither being invested in, nor are they desired by the U.S. manufacturers for the foreseeable future. They must, somehow, get a return on their present investment in plant and tooling, designed to produce present-generation products. As a result, the only new heat pumps we see entering the marketplace are units with two "present-generation" compressors instead of one (for modulation), improved controls, and more heat exchange surface.

Unfortunately, without substantial help from EPRI or DOE, the U.S. electric heat pump marketplace will soon become very vulnerable to foreign incursions.

While our own manufacturers have been set back, the Japanese and German interests are actively seeking advanced, high-efficiency, revolutionary products with which to expand into the international marketplace. One can envision, in about five years, major incursions into the U.S. marketplace by Japanese and European advanced models. With increasing demand by the public for cost-effective high efficiency, the foreign units should sell well, further negatively impacting American heat pump manufacturers.

Three years ago, it was questionable whether or not government funding was needed in the electric heat pump area. Unfortunately, with the present market situation, revolutionary improvements will only come from government involvement.

Gas Heat Pumps

The gas heat pump program was virtually nonexistent until Congress, for FY 1979, increased the DOE budget to initiate a significant, competitive program. All of the the things projected and testified to in that time period have, indeed, happened. In FY 1979 and FY 1980, the DOE heat pump program initiated several promising contracts to support technologies which can, at a minimum, provide the needed space heating now supplied by furnaces, using half the gas (or oil) now used. This is accomplished by "pumping" energy from the outside air into the house (or building) in the form of heat. The contracts are cost shared, and are a model of how DOE can work with the private sector to evolve revolutionary products of high potential national benefit.

In the 1981, 1982 and 1983 time frames, many of these concepts will be completing laboratory prototype development and will be ready for multi-unit field testing. This will, of necessity, require increased funding from the present laboratory development program. Based on the field test results, the best options should be selected for market testing.

If the DOE program is properly funded, the gas heat pump technologies should be ready for market introduction at about the time the market is ready to receive them, due to the gas price accelerations. This concurrence of events will probably take place in the mid-1980s. Since about half the commercial and residential structures are space heated with gas, and since present furnaces and chillers have about a 20-year lifetime, the savings (near and mid-term) from the implementation of gas heat pump technologies could obviously be immense. The American gas industry should be complemented for their attitude towards this improved efficiency technology since their marketing segments stand ready to help, in every way allowable, with the commercialization of gas-fired heat pumps, and another very promising end-use technology, fuel cells.

EXHIBIT 4

SUMMARY OF SOME GAS-FIRED HEAT PUMP CHARACTERISTICS
(Source: Gordian Associates Inc. 2/)

	Free Piston Stirling/Rankine	Steam Turbine/ Rankine	Combustion Gas Turbine/Rankine	Linear Gas Engine/Rankine	Organic Fluid Absorption
Prime Contractor	GE-Space Div.	Cons. Nat. Gas	Garrett-Airesearch	Columbia	Allied Chemical
Other Participants	DOE, GRI	DOE, MTI	GRI	Tectonics	GRI, Phillips Engr.
Engine					
Thermodynamic cycle	Stirling	Rankine	Brayton	Otto	
Power	3 kW	31 HP (23 kW)	13 HP (9.6 kW)		
Power Fluid	Helium	Steam	Combustion gas	Combustion gas	
Efficiency	32-36%	23%	27%	33%	
Frequency	30 Hz	830 Hz	1170-1500 Hz	Variable	N.a.
Coolant	Glycol-water	Glycol-water	Air		
Fuel(s)	Gas (other fuel, solar)	Gas, fuel oil	Gas, fuel oil	Gas	Gas
Self-starting	Yes (in vertical configuration)	Yes	No	No	
Heat Pump					
Thermodynamic cycle	Rankine	Rankine	Rankine	Rankine	Absorption
Refrigerant	R-22	R-11	R-12	R-22?	(Fluorocarbon (aromatic hydrocarbon absorbent)
Compressor Type	Reciprocating (interial),	Centrifugal, open	Centrifugal, hermetic	Reciprocating, hermetic	
Cooling (95°F) Capacity, Btuh	36,000	90,000*	120,000	240,000	36,000
COP	0.79	0.73	1.0	-	0.5
Heating (47°F) COP	1.5	1.5	1.2	-	1.2
Heating (17°F) COP	1.3	1.3	N.a.**	-	1.1
Other Data					
Electrical power required	Yes	None (generates 8kVA own power)	Yes	Yes	Yes

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* "Breadboard" unit; prototype scale $1x10^6$ Btuh.

** Not available.

INDUSTRIAL EFFICIENCY IMPROVEMENT

Mr. Chairman, a model office for knowing how to act in concert with the private sector and how to accelerate highly beneficial technologies into commercial practice is DOE's Office of Industrial Conservation. I have been closely involved with this office since it was part of ERDA in 1975. It has steadfastly set goals and worked with the private sector to achieve them. I have watched the office survive under some outside disbelief and continual OMB budget cuts until, today, it is generally thought to be the most successful office in Conservation and Solar Applications, if not the most successful in DOE. Yet, its budget remains very small, in fact not much bigger than it was in 1975. It is submitted at $58.9M.

In FY 1981, this office can readily and effectively spend $50 million in addition to its submitted budget, in areas which will increase productivity and lower energy costs; items which are key solutions to our dual energy/inflation problems.

Industry has done a good job of "housekeeping" by installing insulation and such old technology as boiler economizers, and a few improved process designs are going into place. However, the high-technology, high-payoff advances require increased funding, and must be demonstrated for a period of at least two years before they can be sold commercially, regardless of Discounted Cash Flow analytical results. A product line manager, responsible for the reliable and continued production within a plant, requires that every new piece of equipment for his product line have a history of at least two years of trouble-free installation, in a process similar to his own, someplace else.

Over the past two years, the Department of Commerce has led a study to examine the nation's receding position in international markets, and how this position might be improved. A salient result of this study is the need for industrial innovation, with federal assistance. It is clear that our international competition has found ways to form government-industry alliances leading to broad industrial innovation. This, in turn, has resulted in a high degree of industrial productivity and energy productivity in these countries, further resulting in an improved competitive position for them in the international marketplace.

A salient result of this last two year's studies is that technological innovation leading to industrial innovation can be catalyzed by an atmosphere conducive to risk taking. Minimizing risk will maximize innovation.

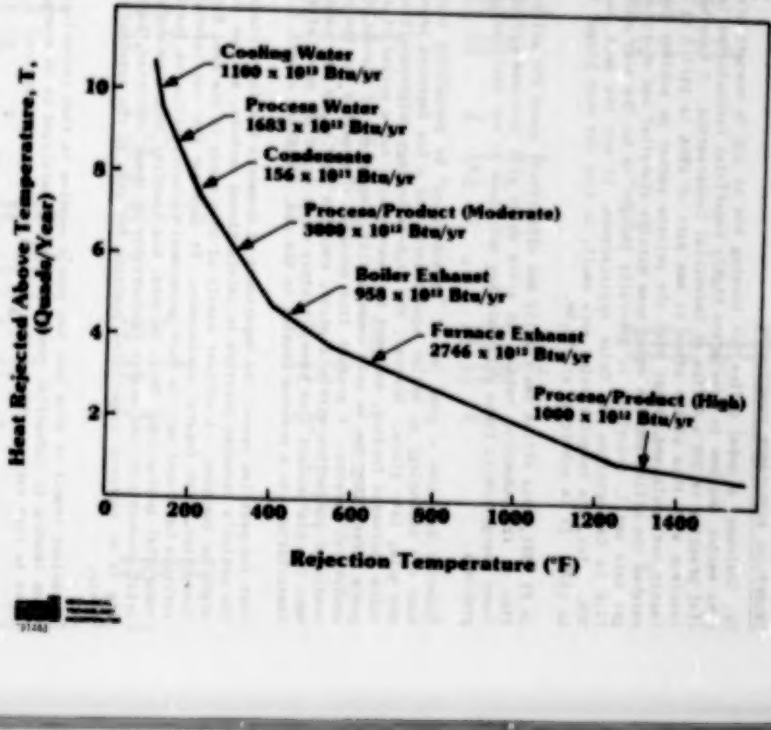
There are presently three major areas of risk to be addressed:

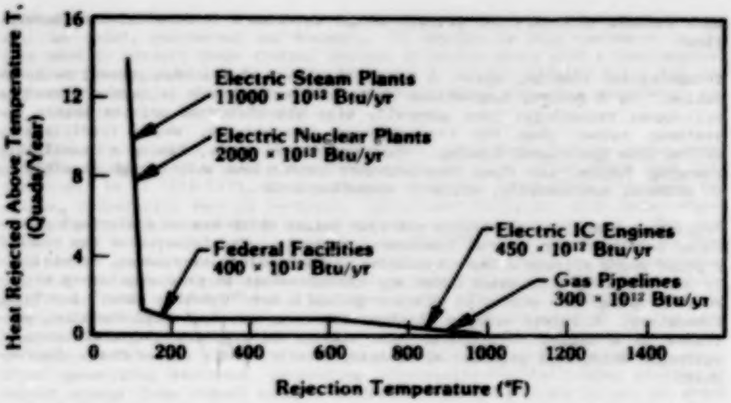
a) financial risk
b) technological risk
c) regulatory risk.

Financial risk has always been present in technological innovation and can be addressed with Discounted Cash Flow (DCF) or Return on Investment (ROI) or Internal Rate of Return (IRR) analyses. Analytical tools are present to address these factors in precision fashion assuming such values as energy costs and marketplace factors can be accurately predicted. Today, the error bands on future predictions are so wide that financial returns can generally be predicted with confidence for only one or two years hence. Therefore, there is a

EXHIBIT 5

Distribution of Industrial Waste Heat Flows





Ref: Energy Information Agency Annual Report

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EXHIBIT 6

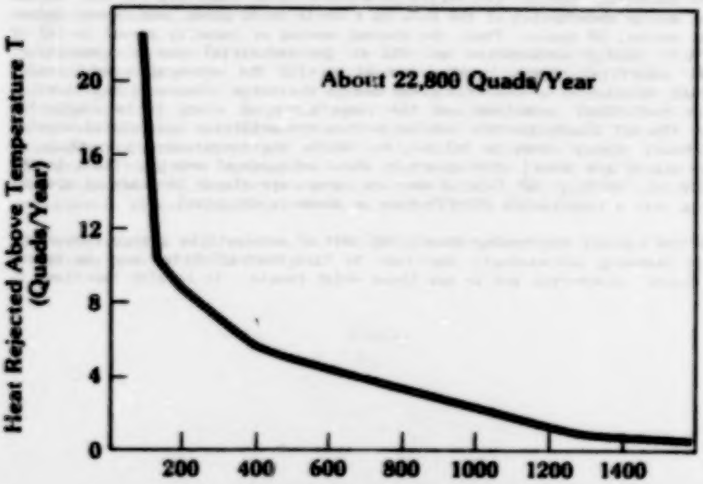

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EXHIBIT 7

much reduced incentive for private sector investment in revolutionary innovation.

Technological risk is, again, a factor which has always been present in innovation. As a result, innovations which are evolutionary in nature (based on well-known technology) have generally been the choice of private sector investment rather than the revolutionary improvements, which traditionally evolve from government funding. What the nation needs, facing a drastically changing future, are those revolutionary innovations with enough flexibility to address, successfully, whatever scenarios occur.

Regulatory risk is a relatively new risk factor which has no analytical procedures developed for careful investment analysis. Regulatory risk has reached a point where private sector innovation, in a revolutionary sense, is virtually not a viable investment under any circumstances where a regulatory structure is going into place, or where regulators are "thinking about" involving themselves. A recent example of this risk is an internal FERC decision, published as a notice of proposed rule making, to regulate the efficiency of equipment which will generate electricity from presently wasted heat. Incredible.

With these substantially increasing risk factors, and with international firms making substantial inroads into our marketplace, the government simply must play an increasing role in working successfully with industry to induce innovation. An excellent start would be to increase the DOE Industrial budget from $58.9M to $108.9M with a $50M add-on. It is an essential investment for the nation to make.

The industrial area I would like to address specifically is that of industrial waste heat in the range of 200°F to 800°F. In this temperature range, no "off-the-shelf" equipment is presently available to convert the heat to either electricity or shaft horsepower. Commercial equipment to utilize this heat has not been developed prior to this time purely because the energy economics were not favorable, and the concurrent perceived risks were too large. The energy that is currently being discharged from U.S. industrial plants to the air and rivers of America can be a new and substantial energy supply through the use of appropriate energy productivity technologies. These thermal discharges amount to about 11 quads. Exhibit 5 presents the distribution of these industrial thermal discharges as a function of temperature. The current total energy consumption of the U.S. as a whole is 78 quads, and of the industrial sector, 28 quads. Thus, the thermal wastes of industry amount to 14% of the U.S. energy consumption and 39% of the industrial energy consumption. These industrial thermal wastes are attractive for conversion into useful thermal, mechanical or electric power due to the large volumes of heat involved at individual locations and the temperature at which it is available. Other thermal discharges are available from the utilities and federal uranium enrichment plants shown in Exhibit 6. While the temperature potentials of these wastes are lower, they amount to about 13 quads of energy. Thus, in the industrial, utility and federal sectors, there are almost 24 quads of thermal wastes with a temperature distribution as shown in Exhibit 7.

With the rapidly increasing escalating cost of exhaustible energy resources, it is becoming increasingly important to find cost-effective ways to reduce the thermal discharges and to use those which remain. It is also important to find ways to effectively use renewable (inexhaustible) thermal energy sources such as solar, geothermal and biomass. Of concern in this testimony is the form used to convert these thermal sources to useful power with a heat engine. At lower temperatures such as are addressed here, the Rankine cycle has the highest realizable efficiency (i.e., available from operating machinery) and is, therefore, the logical choice.

The DOE program which has addressed the steam and organic Rankine cycle technologies applicable in this temperature range has been called Waste Heat Utilization. In FY 1977-1978, the Department of Energy (then ERDA) initiated two unique, cooperative venture contracts (government/industry) with corporations for the purpose of commercializing waste heat utilization equipment. The contracts are 5 years in duration, ending in FY 1982, and are designed so that substantial cost share is involved to build a business base as the government pays for the necessary R&D and assumes a substantial part of the "first equipment" risk due to the potentially high payoff. To date, Sundstrand and Mechanical Technology Incorporated have carried out their portions of the contracts, through implementation of first technical/economic feasibility units and substantial cost share. Prototype power plants have been placed in municipal generating stations, generating electricity by reclaiming previously wasted energy from diesel exhaust manifolds, and cost share is on, or ahead of, schedule. Two other smaller contracts, with other contractors, have also been let for advanced equipment development.

The next phase of the program includes the identification of near-term commercial market installation sites; with MTI addressing advanced steam-Rankine and organic-Rankine systems, and Sundstrand addressing a range of organic-Rankine systems. This is to be followed by a gradual introduction of the equipment into the commercial marketplace. All technical and economic performance measures appear to be proceeding on target through FY 1980. In the MTI contracts, commitment from a large utility has been obtained for an advanced steam cycle unit, and negotiations are proceeding to place ORC units in petrochemical and chemical industries.

In the recent DOE reorganization, happening at the same time as the FY 1981 budget generation, the program was apparently overlooked, with two DOE entities each believing that the other would be responsible for the program. As a result, the program remains in Fossil Energy with no funds to continue it, while $3.4 million (much less than needed) was submitted in the Conservation budget submission to Congress.

As of now, the total joint funding has resulted in the program being on schedule and meeting goals. At MTI, an advanced second-generation design organic unit is going on test, and it is expected that the first installation sites in a large utility and a large refinery will be finalized. Interest in future sales has already been demonstrated and several commercial clients are in the process of submitting budget authorizations for systems in the future. It appears certain that many firms will place orders, based on the successful completion of the contractual program. About 4500 MW of orders by 1985 is conceivable with savings equivalent to over 200,000 BOE daily.

The programmatic requirements in FY 1981 for the continuation of the ongoing contracts consist of basically:

1) Continuation of the contracts, on schedule with some possible programmatic acceleration, accelerating product introduction.
2) Expanded installations due to customer requirements.
3) Technology advancements, contractually required.
4) Advanced and larger systems designs.

The FY '81 funds will buy the enhanced market acceptance originally conceived and will leverage a minimum of 25% share, contractually required, from the contractors. FY '81 needs are expected to be $10.2M.

ENERGY CONVERSION AND UTILIZATION TECHNOLOGY

The final area critically needing the committee's attention is that of the technology base required for accelerated technological innovation in hardware. With the initiation of ERDA, a division called Conservation Research and Technology was formed under the Office of Conservation. It was this division's function to provide a technology base in combustion, tribology, heat exchange, advanced cycles, and fuel cells such that technically innovative, viable equipment could evolve in an accelerated fashion. With the reorganization of ERDA into DOE, this division was moved to Energy Technology where it rapidly took a back seat to coal priorities. Within the last two years, the technologies which were begun in ERDA have suffered drastically. We see, this year, the reemergence of a Division of Advanced Conservation Technology within Conservation and Solar Applications; however, it is critically under-funded at $11M. It needs at least $25M to continue, at a minimum level, those efforts which have nearly been completely lost.

This division is essential to two groups. These first of these is the group of existing divisions within Conservation and Solar Applications; i.e., Transportation, Industry, Buildings and Community Systems, and Solar Applications. The Energy Conversion and Utilization Technologies (ECUT) will compliment these other divisions by providing a technological base from which advanced components can be provided for revolutionary equipment options. The second group to be addressed is in the industrial community which will utilize the evolving technologies in revolutionary products.

Items to be addressed include combustion processes for the range of fuels expected in the future; fuel-flexible combustion components to accept a wide range of bio-derived, synthetic, and conventional fuels; chemical processes for possible development into primary metals refining processes; advanced engine concepts for more efficient, environmentally acceptable, energy conversion; electrochemistry for improved fuel cells; tribology for more efficient lubrication and a reduction in wear; advanced heat exchanger concepts; burner systems for maximum heat exchange with minimum pollution; and a wide variety of similar, high-payoff technologies not ordinarily funded privately.

When this division left Conservation and was moved to Energy Technology, it had a budget over $50M. With its reinstatement, its budget of $11M is much too small. $25M could be effectively and productively spent.

CONCLUSION

Mr. Chairman and members of the Committee, I repeat the need for the government and industry to end their adversary relationship, and join forces to place our nation in a secure position.

On the occasion of this testimony, the United States is locked into an economic and technological struggle of exceptional intensity. The battleground is every home, office, automobile and factory in the United States, and the weapons are the supply, conversion and end use of energy. An essential need for our security and maintenance of living standard is multifaceted technological innovations for improved energy productivity. The fact is that, to date, we have not been successful in our energy efforts. The future controls us; we don't control it; and as long as we are in that mode, we have not succeeded; and the American way of life and standard of living are substantially at risk. It is up to Americans everywhere, in government and industry, to regroup, dedicate even more of ourselves to this effort, and work together to overcome our energy malady because, very simply, our futures, our children's futures, and their children's future hang in the balance. Thank you.

REFERENCES

1. **Hirst, E., and Jackson, J.R., "Future Energy Use in Residential and Commercial Buildings: Energy Conservation and Economics," Oak Ridge National Laboratory report under DOE Contract W-7405-ENG-26.**

2. **"Energy Capital Formation," DOE report by Management Technology Division, STSC, Inc., Bethesda, MD; January 17, 1980.**

3. **Sternlicht, B., and Colosimo, D.D., "New Perspectives on Rankine Cycles," ASME Publication 80-DGP-36.**

Senator **Matsunaga**. Thank you very much, Dr. Lawrence. I cannot agree more with you in your last statement. I think we have to lick this energy crisis. We must really act in every area, and every one of our citizens must be involved. I agree wholeheartedly with you.

And I am somewhat elated to hear your testimony because I think you have touched upon an area we have neglected altogether too much.

Now, what would you say the fuel economy goals of the Stirling engine program are?

Dr. **Lawrence**. The goals of the program, Mr. Chairman, are those set by the Automotive Propulsion Research and Development Act of 1978, which we frankly think are conservative for the potential of the Stirling engine. That goal is to have an engine by 1984 to operate at a high enough efficiency so if the engine is switched one for one for a 1980 internal combustion engine a 30-percent improvement will be realized.

Senator **Matsunaga**. There are certain Members of Congress who are thinking of setting a minimum of a 40-mile-per-gallon average by 1995 upon the automotive manufacturing industry. Could the Stirling engine compete with the alternatives that would need to be used in order to meet that goal?

Dr. **Lawrence**. I think I can say with a lot of confidence, Mr. Chairman, there should be no problem with it, not only competing, but beating the other alternatives. The Stirling engine has the highest potential thermodynamic efficiency, it delivers more power of fuel-in than any other alternative. Therefore, if this program is successful, then the automobile configuration and size and weight and aerodynamic design incorporating an internal combustion energy in 1995 to meet that particular standard could have its miles per gallon increased by 30 percent by incorporating a Stirling engine instead of the internal combustion engine.

Senator **Matsunaga**. Could you briefly explain how that operates?

Dr. **Lawrence**. Yes. The Stirling engine operates first of all like an internal combustion engine where you explode a mixture of gasoline and air and push a piston down. In the Stirling engine you have a flame in what is called a heater head, a combustion device where the heat is transferred to an internal working fluid sealed within the engine. Alternatively, in the piston cylinder space, the space is first heated, which provides the high pressure pushing the piston down and then cooled, providing a low pressure which helps the piston to return very easily. That is basically how it works.

The fact that you can use an external flame allows you to burn very efficiently and cleanly, which is why we have actually beaten the 1985 standards with these automobiles. It also allows you to use a wide variety of fuels and still maintain this flame without changing anything in the engine.

We had a demonstration automobile up here on the Hill, Mr. Chairman, where we had enough confidence in it to allow Members of Congress to go ahead and select the fuel in the back of the car and then proceed to drive the car. So this is where the program begins.

Senator **Matsunaga**. With regard to heat pumps, how do the efficiencies of gas and electric heat pumps compare if you take into account losses in generating electricity, and how do the projected costs for gas heat pumps compare to other alternatives?

Dr. **Lawrence**. OK, Mr. Chairman. In terms of—first of all, let's talk about an electric heat pump, because the first electric heat pumps are commercial items now. We will see advances coming along. If we assume a rough number of 30 percent generation efficiency, so that electricity delivered to a structure for the purpose of conversion to an end-use is already considered to be 30 percent efficient and we then operate an electric heat pump which could have a coefficient of performance as high as 3, we multiply—as a matter of fact, the new ones are 3.5—if you multiply 3.5 times the 30 percent you wind up with an overall conversion efficiency from fuel to the desired end-use in the home of 1.1, 1.2.

What this means is that by delivering the energy to a motor that operates a compressor, it operates this heat pump system, you actually are able to utilize the energy present in the outside atmosphere and deliver it to the home in such a way that you exceed 100 percent efficiency, if you will, the amount of energy delivered to the system is less than the system is able to provide to the home.

Briefly addressing the gas heat pump question, the gas heat pumps now under development will in the heating mode deliver energy to a home at a COP of 1.4 to 1.8. In the cooling mode they are considerably less efficient due to the fact that there is some waste heat. In a cooling mode it will be more like 1.0 to 0.8. So in a cooling mode it will be slightly less efficient than the electric version and the heating mode will be more efficient. The gas heat pump will more than double the efficiency of a gas furnace for the same amount of gas. For any one-for-one conversion you will save half the gas.

Costwise we are seeing gas heat pumps coming now in the prototype stage having a potential cost of about 25 percent more than the electric heat pump version. However, in operating costs this should be virtually half of furnaces because they use half the fuel.

Senator **Matsunaga**. I do not quite recall now, but are heat pumps now subject to the 10-percent tax credit?

Dr. **Lawrence**. I am not sure either, Mr. Chairman. I know it was discussed substantially, but the last I knew I don't believe that they were.

Senator **Matsunaga**. I think we omitted that in conference, as I recall. The Secretary of Energy has the authority to designate certain equipment as being eligible. Do you feel that heat pumps ought to be accorded that tax credit?

Dr. **Lawrence**. I think that the savings and the benefit to the Nation are such that it would certainly be worthwhile.

Senator **Matsunaga**. It is not within the jurisdiction of this committee; but I am also on the Finance Committee, so I could use that information.

This will be the final question, because I see time fleeing by. I think one of the areas of real energy loss is in our inability or unwillingness to utilize the waste heat in industry. What could you suggest that we in the Congress can do in order to bring about better utilization of wasted heat, cogeneration, you may call it?

Dr. **Lawrence**. The key area of industrial waste heat that we have identified, Mr. Chairman, where the Congress could play a key role, is in that range between 200° F and 800° F, where there is no equipment presently as a catalog item that you could take off the shelf and apply to the industrial waste heat and wind up turning a shaft which could either run a compressor or deliver electricity. Both are high grade forms of energy.

In that area, there is now a very small program in place in the Department of Energy in which we are participating. We are finding that the relationship with DOE is essential to overcome the risk factors involved. Thanks to the DOE participation, and a lot of investment by ourselves, we are now to the point where advanced development and, above all, industrial demonstrations of this kind of equipment is essential to get it into the marketplace.

We are finding that with the increased energy costs we can go to an industry with a process and show them where implementation of this equipment in their process can be an excellent investment against their requirements for discounted cash flow, and things like this. Our problem is, when they ask a question of us, Show me one that has been in operation for 2 years so that I, the production manager, can feel confident in your maintenance schedule. That is the toughest problem, getting that person to go first.

The programs under Doug Harvey, in the industry area, for industrial demonstrations are really essential to getting these things into the marketplace. Doug knows how to do this well. He gets a lot of cost sharing involved and visibility for the programs, and these are needed.

In each process it is the production manager who is going to make the decision. If you do it in a glass process, which operates one way, and there are a wide variety of glass plants with a similar process, these demonstrations are essential.

Senator **Matsunaga**. Do you know of any unsolicited proposals that the private sector has made to the DOE for funding any of these projects?

Dr. **Lawrence**. There are several, Mr. Chairman. We are the authors of one. There are a number of other companies who are very well qualified, who we would like to see funded in addressing their own area. Sunstream Corp., for instance.

Senator **Matsunaga**. What sort of reception have you received?

Dr. **Lawrence**. The reception is good, but the problem is with an industrial conservation program held down to this to produce 36 percent of our Nation's energy, there isn't enough to go around.

Senator **Matsunaga**. All of this boils down to money, does it not? Well, thank you very much, Dr. Lawrence. I wish we could carry on a little more of our conversation. I think you represent a most interesting and promising area which we have, I think, too much neglected.

Dr. **Lawrence**. Thank you very much, Mr. Chairman.

Senator **Matsunaga**. Our next witness is Mr. Benjamin L. Wolff, executive director, American Wind Energy Association, Washington, D.C.

Mr. Wolff.

STATEMENT OF BENJAMIN L. WOLFF, EXECUTIVE DIRECTOR, AMERICAN WIND ENERGY ASSOCIATION, WASHINGTON, D.C.

Mr. **Wolff**. Thank you. It is a pleasure to appear before you again, before the committee, to talk about my favorite subject, wind energy.

I feel as though I am like a preacher preaching to the choir. I know that Hawaii has an excellent wind resource as well as an excellent wind program, and I wish that we could move that along faster, and even replicate that project to other areas.

Surely, the members of the committee must get tired of having a parade of special interest groups coming in asking for additional funds. I am not sure if that represents the success of the system or the failure. The success, because everybody gets heard, or the failure because if the Department of Energy was responsive to the concerns of those of us involved in energy we wouldn't have to be here.

I know of no disagreement with the statement that wind energy is the most near-term of the solar electric options. Machines are being designed and built today which are cost effective in selected applications, and when we manufacture more substantial quantities we will be able to compete with our conventional sources.

It would be easy to limit the analysis of the wind program to the state of the marketplace and the technology. However, that ignores the state of the wind industry, which is very harsh. Mainly, the wind business, even the divisions of larger corporations, is in its infancy and struggling to achieve legitimate status in the marketplace. Achieving the status would be made easier if the government were able to act on its policy of using alternate energies to meet national energy needs. However, the statement of its policy has added pressure by way of prematurely raising expectations about the role alternate technologies can play.

The desire is to have the normal evolution of the development of the energy accelerated beyond what would normally happen. The marketplace is not designed to provide this initial acceleration and the initial push has to come from outside the marketplace to speed the entry of the industry so that further technology development can take place in the normal course of industry development. Until that extra marketplace activity is initiated, the wind energy will be whipsawed by both the hope and promise of unrealistic expectations.

The simple truth is the success of the wind industry today is dictated more by political considerations than technical breakthroughs or economics. As Willian Robbins said in this month's Journal, he states, the barrier which existed when we first started the wind program was that of technology. That has changed. Now what we have to do is be sure that the customer has the right information to accept the technology.

What has the Department of Energy's response been to the early technical success of the program? The fiscal year 1981 budget has the market and impact analysis reduced by over half a million dollars. The information dissemination program is reduced by over $200,000. Wind energy prospecting is increased by only 4 percent. The implementation and market development section of the program is reduced from over $2 million to zero. Instead, they propose to increase technology development by $4 million, and engineering development by $15 million.

The problems here are not unique to the wind industry. As the National Security Industrial Association told the White House last week, the tendency of the technocracy is to pursue the possible without implementing the achievable. Few people would take the position that wind machines wouldn't benefit from further technology development. However, the nonhardware issues facing the industry now have a longer leadtime than the further development of the technology. This includes a better understanding of the wind resource, development of industry infrastructure, both in terms of sales and service and component suppliers and market identification and segmentation. This has been realized by a number of outside observers.

In title VIII of S. 932, which is now in conference, a budget of $100 million is proposed for fiscal year 1980. The President's Domestic Policy Review recommended a budget of $100 million for fiscal year 1980. There was a public panel review in August of 1978 that recommended the minimum threshold budget for early commercial viability for the wind industry would be $100 million in 1980. But somewhere in the chain between the Department of Energy management, the Office of Management and Budget, and the Congressional Appropriations Committee, the wind program has been derailed. The appropriations for last year was $63.4 million, less than the House authorization, less than the Senate authorization, less than the House appropriation, less than the Senate appropriation, less than OMB's request to Congress.

This $63.4 million severely constrained the ability of the program to meet objectives.

If the committee agrees that it is in the national interest to maximize the contribution of renewable energies to the national energy supplies as early as possible and as early as they become cost-effective, the options are somewhat limited.

We have prepared detailed budget recommendations of the Department of Energy budget that would result in a fiscal year 1981 budget of $115 million. This is consistent with all the reviews of the DOE wind program we have seen adjusted for inflation. I have attached the recommendations to my testimony for your consideration.

I would like to thank you for giving me this opportunity to express the views of my constituents. I am sorry I couldn't in good conscience tell you that wind energy needs less Federal support. However, with your help, the tail won't be far off.

[The recommendations referred to by Mr. Wolff follow:]

The American Wind Energy Association

DOE

WIND PROGRAM

BUDGET RECOMMENDATIONS

FY 1981

24 March 1980

1621 Connecticut Ave. NW, Washington, DC 20009 tel. (202) 667-9137

SUMMARY of Recommendations for the FY 1981 DOE Wind Program

The potential contribution of wind energy to National energy supplies is generally agreed to be substantial. DOE commercialization plans suggest wind could provide over 3 Quads by the year 2000 (2 from large systems, 1 from small). The Domestic Policy Review suggests a range from 1.7 to 3 Quads (considering only large machines). The General Electric Mission Analysis suggests a satruation level for selected applications of 13 Quads. A review of DOE's solar programs conducted by SRI (A Question of Program Balance) suggests a technical limit for wind energy of 29 Quads. The exact timing and magnitude of the contribution is a political rather than a technical question.

The role of the Federal government stems from the fact that, as a matter of public policy, the development and application of renewable sources of energy is being accelerated beyond what would occur in a 'free market' economy. Also, there is a higher degree of risk associated with the uncertainty of government energy policy. A final aspect, at least of the near-term Federal role, is that the majority of activity in the wind industry today is either directly or indirectly supported by the Federal government.

In this context, the scope and pace of the Federal wind program is crucial to the wind industry. We have undertaken a careful review of the DOE program represented by the FY 1981 budget request, and have recommended a number of new initiatives. These recommendations are consistent with the goals and objectives of the wind legislation now being considered. What follows is a summary of those recommendations by major program area and a detailed description of the specific programs. DOE budget documents were used as the source for the description of the present programs.

RESEARCH AND ANALYSIS

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 7,569	$ 8,739	$ 7,700		$ 11,945	$ 16,400

Constrained Recommendations:

- **Interagency analysis of possible Federal actions in National and international commercialization**
- **Public sector (Federal, State, and local) market analyses for large, intermediate and small systems**
- **Federal, State and local agency information dissemination programs.**
- **A Wind Energy Information Center.**

Expanded Recommendations:

- **Utility planning grants**
- **Support for State Public Utility Commissions**
- **Aggressive information dissemination program**

WIND CHARACTERISTICS

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 4,947	$ 5,401	$ 6,200		$ 8,700	$ 12,700

Constrained Recommendations:

- anemometer loan program
- expanded Program Opportunity Notice site evaluation program

Expanded Recommendations:

- 'forgivable loans' for feasibility studies

TECHNOLOGY DEVELOPMENT

FY 1979	FY 1980	FY 1981	AWEA	Constrained	Expanded
$ 10,048	$ 13,181	$ 17,100		$ 22,850	$ 33,850

Constrained Recommendations:

- Expansion of Rocky Flats test facilities
- Directed procurments and unsolicited proposals for component technology development

- Vertical axis supporting research and technology

Expanded Recommendations:

- Regional test centers for small systems
- Expanded test facilities for vertical axis program

ENGINEERING DEVELOPMENT

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 33,391	$ 34,071	$ 49,000		$ 66,500	$ 86,500

Constrained Recommendations:

- Design competition in upper end of small spectrum, 60-80 kw
- Purchase of five Mod-5 machines
- Increase value of Mod-5 contracts
- Addition award of horizontal axis Mod-6

Expanded Recommendations:

- Purchase of additional early prototype (small) systems
- Additional development of vertical axis Mod-6
- Purchase additional early large scale systems

IMPLEMENTATION AND MARKET DEVELOPMENT

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 4,700	$ 2,000	0		$ 5,000	$ 13,000

Constrained Recommendations:

- Continuation of Field Evaluation Program

Expanded Recommendation:

- Feeder line saturation
- Support of State agencies and utilities

SUMMARY: Total Wind Program Budget

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 60,655	$ 63,392	$ 80,000		$ 114,995	$ 162,450

DOE Wind Program Budget: FY 1979-1981

AWEA Recommendations

($1,000's)	FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
RESEARCH & ANALYSIS						
Market & Impacts	$ 6,254	$ 6,719	$ 7,700		$ 8,085	$ 9,785
Innovative Concepts	962	1,456	1,255		500	1,255
Info. Dissemination	353	564	360		3,360	5,360
TOTAL:	$ 7,569	$ 8,739	$ 7,700		$ 11,945	$ 16,400
WIND CHARACTERISTICS						
Wind Prospecting	$ 1,857	$ 2,516	$ 2,700		$ 3,700	$ 7,700
Support for D&O	1,090	1,239	1,500		1,500	1,500
Site Evaluation	2,000	1,646	2,000		3,500	3,500
TOTAL:	$ 4,947	$ 5,401	$ 6,200		$ 8,700	$ 12,700
TECHNOLOGY DEVELOPMENT						
Small Systems	$ 4,457	$ 6,313	$ 8,260		$ 10,010	$ 20,010
Intermediate Systems	4,549	5,586	7,840		9,840	9,840
Evolving Technologies	1,042	1,282	1,000		3,000	4,000
TOTAL:	$10,048	$13,181	$17,100		$ 22,850	$ 33,850
ENGINEERING DEVELOPMENT						
Small Systems	$ 7,267	$ 7,685	$10,000		$ 11,000	$ 13,500
Intermediate Systems	5,769	2,303	13,800		$ 19,300	$ 24,800
Large Systems	20,355	24,083	25,200		36,200	48,200
TOTAL:	$33,391	$34,071	$49,000		$ 66,500	$ 86,500
IMPLEMENATION & MARKET DEVELOPMENT						
TOTAL:	$ 4,700	$ 2,000	$ 0		$ 5,000	$ 13,000
TOTAL:	$60,655	$63,392	$80,000		$114,995	$162,450

SPECIFIC WIND PROGRAM RECOMMENDATIONS: FY 1981

Introduction

During this review of the DOE wind program, a number of shortcommings have become obvious. Although each are interrelated and to a large degree, flow from the first, they are:

- There is a lack of sufficient resources to meet goals in a timely fashion. This has been recognized during DOE's Public Review of Solar Program, August 1978: the Domestic Policy Review and legislation now pending in Congress.
- There is a program bias toward technology development and hardware programs. This has been dictated by the DOE management structure, the Office of Management and Budget1 and, the lack of adeaquate resources.
- The emphasis of the current program is on utility applications of wind energy which requires substantial technology development, at the expense of resolving non-technical issues and the barriers facing the distributed applications of wind energy.

Realizing that in the present economic and political environment, constrained funding may be a fact of life, two budget recommendations are given for each program element. The first is a minimum budget, consistent with the recommendations in the DPR adjusted for inflation, and pending Senate legislation. The second is an expanded program, designed to achieve the goals set forth in previous DOE commercialization plans.

1.0 Research and Analysis

Background

Principally under the direction of the Solar Energy Research Institute (SERI), this program element seeks to provide a basic understanding of wind system economic and operational requirements in each application, investigate the economic potential of innovative wind energy concepts, assess institutional/environmental impacts, and disseminate information to potential users and industry.

FY 1981 Budget (funding in $1,000)

a. Market and Impact Analysis

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
6,759 $ [illegible]	$ 6,719	$ 6,085		$ 8,085	$ 9,785

The present program includes the completion of initial market analyses being conducted by contractors for Rocky Flats and SERI: assessment of environmental issues; the development of planning and economic handbooks: analysis of incentive options and cost: continued reassessment of program strategy to balance cost, time and risk.

Additional Programs under a Constrained Budget

Analysis of possible Federal actions in support of domestic and international commercialization. This would be an interagency activity.	$ 1,000*
Prepare Public Sector (Federal, State and Local) market analysis for large, intermediate and small scale systems.	$ 1,000

Additional Programs under an Expanded Budget

Utility planning grants to assess the integration of wind energy with capacity expansion plans.	$ 2,000
Technical and financial support for state Public Utility Commissions in the implementation of the Public Utility Regulatory Policies Act (PURPA)	$ 1,500

b. Innovative Concepts

FY 1979	FY 1980	FY 1981	AWEA	Constrained	Expanded
942 $ [illegible]	$ 1,456	$ 1,255		$ 500	$ 1,255

The present program provides for continued research and investigations into innovative wind system concepts to assess their potential to offer improvements over conventional systems. Examples include the vortex augmentor, Venturi, and tethered systems.

c. Information Dissemination

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 353	$ 564	$ 360		$ 3,360	$ 5,360

This program identifies and develops various information packages by user class. The primary results to date have been a USDA film and a slide show produced by SERI. FY 1981 plans include defining the roles of Federal and State agencies in the information dissemination process.

Additional Programs under a Constrained Budget

Existing Federal programs and State and local agencies' role in information dissemination should go far beyond the definition stage suggested for FY 1981. Some have programs in place that very much need information on wind to fulfill their mission. Example include EES, Agricultural Extension Service, State Energy Offices, etc. The addition funds recommended would permit contacting these groups, determining their needs and developing material to address those needs. $ 1,000

A Wind Energy Information Center, analogous to the Solar Heating and Cooling Information Center is desperately needed to provide information not only to the general public, but to allied professional fields as well. $ 2,000

Additional Programs under an Expanded Budget

An aggressive information dissemination program that should include at a minimum: an overall strategy that identifies 'target audeinces', their information requirements, the the optimum delivery systems: a wind energy news service that provides press releases to newspapers and periodicals: and, a program to develop educational materials for the broad spectrum of educational institutions including primary, secondary, trade, and universities. $ 2,000

Wind Characteristics

Background

Basic understanding of the wind characteristic impacts the economics in two ways: the loading of the blades and tower directly affect the ccst of the systems; and the wind resource is highly variable from location to location and, hence, the selection of a good wind site directly impacts energy capture with a resulting effect on cost of energy to the user.

a. Wind Energy Prospecting

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ ~~[illegible]~~ 1,957	$ 2,516	$ 2,700		$ 3,700	$ 7,700

The major emphasis of this activity is to assess the wind resource and identify the most favorable wind regions. A refined assessment of the wind resource for the Northwest region has been completed and work on the remaining regions is underway.

Additional Program under a Constrained Budnet

Institution of an anemometer loan program to be administered through the Regional Solar Energy Centers (RSEC's). This program would provide hardware and technical support for potential users of wind energy in a region. Empahsis would be placed on the distributed applications of wind energy for agricultural, commercial, industrial and residential users.	$ 1,000

Additional Programs under an Expanded Budget

A revolving fund available for 'forgivable loans' for site prospecting and feasibility studies should be made available for large scale wind developments. It the project goes forward after the feasibility study the prospecting cost is rolled into the construction cost. If the project dosen't go ahead, the loan is forgiven. This is similar to a program in low head hydro, and geothermal.	$ 2,000

Existing NOAA and U.S. Weather Service stations should be upgraded in terms of anemometer equipment, data collection and reduction, and anemometer location to optimize existing stations for wind resource data collection. Additional weather stations should be provided where necessary. $ 3,000

b. Support for Design and Operations

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 1,096 ~~[illegible]~~	$ 1,239	$ 1,500		$ 1,500	$ 1,500

The accomplishements of this activity includes the evaluation of gust models for use in fatigue analysis; analysis of power outputs from experiemntal machines; and the production of wind forcasting models.

c. Site Evaluation

FY 1979	FY 1980	FY 1981	AWEA	Constrained	Expanded
$ 2,000 ~~[illegible]~~	$ 1,646	$ 2,000		$ 3,500	$ 3,500

The primary activity of this program includes the selection of candidate sites for the Mod-2 and prototype machines.

Additional Programs under a Constrained Budget

The Program Opportunity Notice used to solicit utility response to being a 'candidate site' for future prototype test programs doesnot go far enough. The PON program should be expanded to provide financial and technical assistant to utilities and users who are attempting to explore their wind resource, without reference to receiving a future DOE prototype machine. $ 1,500

Technology Development

Background

Provides the technical basis for reduced cost and improved performance of advanced wind systems and their components. The intermediate-scale Mod-0 test bed has been operational since 1975 under NASA Lewis and has been used to evaluate a wide range of alternative configurations and components.

The small systems test center at Rocky Flats has been operation since 1977 and now has 16 commercially available systms under test. The primary increase in the budget over FY 1980 will be used for sub-system and component R&D activities.

a. Small Systems Technology

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expended
4,457 $[redacted]	$ 6,313	$ 8,260		$ 10,010	$20,010

The FY 1981 budget request provides for the continuing operation and maintenance of the Rocky Flats Test Center and $1,400,000 for supporting capital equipment. It also provide for six ongoing USDA experiments in non-electric end use application.

Additional Programs under a Constrained Budget

The capabilities of the Rocky Flats test center should be expanded in three major areas:

- Atmospheric test facilities
  - expansion to 45 sites
  - purchase of additonal machines
  - purchase of additional prototypes 500
- Special test systems
  - vibration testing
  - dynamometer testing
  - controlled velocity tests 750
- Power management system
  - electrical test support
  - power lab expansion 500

Additional Programs under an Expanded Budget

The Rocky Flats test center is extremely atypical in the nature of the winds experienced. Additional regional test centers should be established that provide long term operational data in a range of environments. These additional test centers could also be designed to explore regional applications of wind; provide local information dissemination services; and educational facilities for visitors and research. $10,000

b. Intermediate and large System Technology

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ [illegible]	$ 5,586	$ 7,840		$ 9,840	$ 9,840

The FY 1981 budget request in this program provides continued research and technology development on rotor systems as the major cost component of wind systems. Specifically, this includes developing and testing advanced techniques for controlling rotor power output to reduce design loads and improve performance. The rotor systems activities also include the testing of blades made from advanced materials and fabricating techniques.

Additional Program under a Constrained Budget

An additional fund should be developed for directed procurements and unsolicited proposals to support work on component and systems development that falls outside the normal program procurement process. This effort should be designed to bring potential component suppliers not presently involved in the DOE program and to apply the technology from other industries to component and systems development.	$ 2,000

c. Evolving Technologies

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ ~~[illegible]~~ 1,042	$ 1,282	$ 1.000		$ 3,000	$ 4,000

This budget request provides for research and investigation into the structural dynamics and design improvements for the Darrieus vertical axis system and. to a lesser extent, other approaches from the innovative programs. A review of the Darrieus system showed significant potential for being competitive with conventional systems and a substantial portion of the funding was transfered to engineering development (following).

Additional Program under a Constrained Budget

The Darrieus program remains at least a generation of technical development behind the horizontal axis systems because of early program emphasis. Substantial additional efforts are required to recover this step, before the systems are able to compete on a equitable basis. The programs under this expansion include investigation of gear box and other mechanical power transmission systems; cambered airfoils; improved vertical axis aerodynamics performance analysis; additional projects for fabricating larger composite blades; further study of erection procedures; and, further refinement of rotor controls. $ 2,000

Additional Program under Expanded Budget

Exapnd and upgrade existing vertical axis test-bed facilities to permit continued evaluation and validation of analysis techniques and proposed improvements. $ 1,000

Engineering Development

Background

This activity provides for a sequence of progressively more advanced machines with lower cost of energy. In general, wind machines currently available provide electricity for 7-12¢ per kilowatt hour, while prototypes under development provide energy for 8-9¢ per kilowatt hour, decreasing to about 4-5¢ per kilowatt hour in production. More advanced systems now underway are projected to provide electricity at less than 4¢ per kilowatt hour. The object of this activity is to design, fabricate and test a series of progressively more advanced machines that approach these costs.

a. Small Systems Development

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 7,267	$ 7,685	$10,000		$ 11,000	$ 13,500

The FY 1981 budget request will provide for the development and testing of the 4 wk and 15 kw systems; product improvement for 5 of the 9 systems completed as part of the first generation of machine developments (1-2 kw; 8 kw; 40 kw); development of a limited number of 2nd generation systems in the 2-20 kw range; and limited testing of the early prototypes.

Additional Program under a Constrained Budget

As the results of the first round of technology development becomes available, it is apparent that the cost projections for machines in the upper end of the small spectrum, namely the 40 kw system, are very competitive with the megawatt-cale systems. "Larage" 'small' machines have significant market potnetial for commercial, industrial and remote applications. The failure of the Department of pursue machines in the upper end of the small spectrum is incomprehensible. This addition would provide for parrellel development of a system in the 60-80 kw capacity range. $ 1,000

Additional Programs under an Expanded Budget

A substantially large number of early prototypes should be purchased 1) for testing in a broad range of climatic conditions including salt environment, dust, ice, and continuous operation; 2) the majority of outstanding questions in the further advance of these machines will require substantial operational experience; 3) many of the firms involved would benefit substantialy from the manufacturing experience of producing a number of machines just beyond the 'hand crafted' prototype construction level. $ 2,500

b. Intermediate Systems Development

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
5,769 ~~$ 2,303~~	$ 2,303	$13,800		$ 19,300	$ 24,800

The FY 1981 budget will be devoted primarily to the development of an advanced intermediate scael machine the Mod-6. Present plans are for the development of one horizontal axis machine and one vertical axis machine.

Additional Programs under a Constrained Budget

The award of parallel development for one vertical axis and one horizontal axis machine is not actually a parrallel development program. The vertical axis technology, although it shows tremendous promise, remains one generation of development behind the horizontal axis technology. Also, for a range of reasons, including general performance characteristics and industry characteristics, the two award winners are unlikely to be competing directly, which effectively removes competition as a driver in cost reduction, one of the main reasons for parallel development programs. Under a constrained budget, an additional contractor for the horizontal axis system should be added. $ 5,500

Additional Program under an Expanded Program

Under an expanded program, parrallel development of the vertical axis machines would also be conducted. $ 5,500

c. Large System Development

FY 1979	FY 1980	FY 1981	AWEA	Constrained	Expanded
20,355 $ [redacted]	$ 24,083	$ 25,200		$ 36,200	$ 48,200

The funding requested for FY 1981 provides for the parallel development (2 contractors) of an advanced megawatt scale system, the Mod-5. The cost of energy goals expected to be acheived in production from this last round of technology development is 3-4¢ per kilowatt hour. This budget request also provides for the continued testing of the Mod-1 in Boone, NC and a three unit Mod-2 wind farm in Washington State.

Additional Programs under a constrained Budget

The greatest remaining obstacle to attaining the objectives of the DPR will utility acceptance. Utilities have continually stated in public and private forums that before they can consider the integration of wind equipment in their capacity expansion plans, they will have to have operating experience. For these reasons, every effort should be made to maximize utility experience. This can be done in part by committing to purchase a number of Mod-5 machines at the completion of the development program. An additional 5 units from each manufacturer would require additional funding in FY 1981 to order long lead time components. $ 4,000

Additionally, based on previous experience with the Mod-1 and Mod-2 program, it is our opinion that the Mod-5 contract costs are underestimated and will hamper the ability of these projects to meet cost of energy objectives. $ 7,000

Additional Programs under an Expanded Budget

For many of the reasons listed above, namely the expansion of utility experience with wind energy, even machines that will not be economically competitive, it is recommended that additional machines be pruchased either outright or one a cost-sharing basis to further involve utility operators. $12,000

Implementation and Market Development

Background

This element addresses the commercialization activities to foster industry/infrastructure development, stimulate market growth, and reduce barriers to commercialization. Based on current technical status, the only activity to date is the Field Evaluation Program which addresses the institutional issues associated with privately-owned small systems interconnected to the electric utility network.

FY 1979	FY 1980	FY 1981	AWEA:	Constrained	Expanded
$ 4,700	$ 2,000	0		$ 5,000	$13,000

The present Field Evaluation program is winding down.

Additional Program under a Constrained Budget

At this point in time, when implementation and market development are crucial to broad spectrum of small and intermediate -scale manufacturers. the elimination of this program is incomprehensible. At a minimum, the Field Evaluation Program should be maintained which would include: the preparation and dissemination of test results· the procurement of additional machines: maintenance contracts to manufacturers to aid infrastructure development. $ ~~4~~5,000

Additional Programs under an Expanded Budget

Additional Programs under an Expanded Budget

The logical extension of the present Field Evaluation program takes two directions: fisrt. a simulation of a feeder line saturation and second continued and expanded support of the State agencies and utilities involved in the program.

The feeder line saturation would study 25-50% system penetration by small wind systems in terms of current harmonics and distortion: voltage variation with wind gusts: power factor and VAR requirements: line losses: and, system protection.	$ 5,000
The expanded support of State agencies and utilities involved in the field evaluation program consists of providing technical and administrative support for interested parties including State regulatory bodies, interested consumers, and Universities. Additionally, it can reasonably expected that in many cases the Field Evaluation Program will generate more questions than it answers. Examples include inquireies for potential users, non-participating utilities, and various State and local bodies. If these questions are not adeaquately addressed, many of the potential benefits of the Field Evaluation Program will be lost.	$ 3,000

Senator **Matsunaga**. Thank you very much, Mr. Wolff. I am inclined to agree with you that one of the potential short-term reliefs in our energy crisis is wind energy, and we have not fully utilized its vast potential.

In Hawaii, which you may already know, we are putting forth full efforts toward becoming energy self-sufficient, and one of the alternative sources we are depending upon is wind energy. We have a projected plan on the island of Molokai, for example, at Ilio Point, which has been selected by the Department of Energy as one of the seven most highly promising areas. We have a constant wind of 16 miles or more, and we propose to have a 62-megawatt electric windpower plant.

We, in Hawaii, hope to become energy self-sufficient in the area of electricity before 1990, I would say.

Mr. **Wolff**. Senator, I am sure wind can play a major role in Hawaii's self-sufficiency.

Senator **Matsunaga**. Yes.

However, with all the tax credit we now provide for the development of wind energy and the small-scale wind energy systems, we have not had too many takers in this area. What can we do to provide further incentives so that people will undertake smaller wind energy systems?

Mr. **Wolff**. Well, I want to preface my remarks by complimenting you on the very forceful and critical role you play as a member of the Finance Committee in instituting the new tax credits that are part of the windfall profits tax. I think that that type of action, that type of incentive, is probably going to do more to commercialize, particularly the distributed applications of wind systems, than almost anything else.

However, so long as the Department of Energy continues to vacillate in funding levels and continues to present both to the Congress and the public that the emphasis of the program should be on technology development, then you, as a user, would be hesitant to purchase a wind system if you had the Department of Energy telling you, just wait 3 years and then you will have the be-all and end-all in new systems.

I think that the problem we are having is that the bias of the programs managers in the Department in general is toward hardware development and technology, and we are not seeing enough attention focused on addressing nontechnical issues. For example, the development of a sales and service infrastructure to get people out there who can install a wind system, and who can service it, and who can answer questions to the public about that.

Once again, the Hill has played a very key role in the passage of ERPA as part of the National Energy Act, and the Federal Energy Regulatory Commission's interpretation of that legislation stands to be a very powerful incentive when combined with a tax credit.

However, there is no bridging mechanism or programs between these marketing development activities exemplified by the tax credits and technology development. There is a whole chain of events that have to occur before we can make the linkup of the Department of Energy's technology and the marketplace incentives. And the majority of our program recommendations are directed to that bridging mechanism.

An obvious example is if you look at the two very important areas in the Department of Energy's budget; namely, information dissemination, I think they request $360,000 for information dissemination for fiscal year 1981. We are recommending that that be increased by $3 million, because we feel as though that is the important area.

Another area is implementation and market development, which specifically addresses this area, which the Department of Energy reduced to zero in the fiscal year 1981 budget. We think that program should be restored.

There is a problem with the bias of the agency and the marketplace initiatives established by Congress. That is what our budget recommendations attempted to address.

Senator MATSUNAGA. Do you agree that one of the real problems in the development of wind energy is in the lack of wind turbines? I will give an example. Representatives from Boeing visited my office to promote wind energy, and I was presented with a model of a windmill which would generate, I was told, as much as 3 megawatts. I was very pleased that they had developed a windmill that would provide as much as 3 megawatts. But when I inquired as to how many of those they could produce within a year, they said about one a month. That is only 12 a year.

What about the availability of small turbines where families could use them? Do you happen to have any idea as to——

Mr. WOLFF. I think current annual sales are running on the order of 1,000 a year. I think we have the technology to make 10,000 a year, but you don't want them sitting on the loading docks just collecting dust. And the businesses involved, either Grumman, a division of a major corporation, or a small firm, they have a difficult time attracting the capital, either through public or private sources, to order the material to make the machines so long as there is no indication of a commitment or an ongoing program.

I think that is the important aspect of title 8 in S. 932. There are two questions there. One is how many could we possibly make, how many could we make, and the other is how many are being made.

Senator MATSUNAGA. As I understand it, California now has a law which requires public utilities to purchase power from the small windmill systems or wind electrical systems. Now, I would think that a law such as that would help to stimulate the adoption of small systems. What do you think?

Mr. WOLFF. The Public Utility Regulatory Policy Act, which was one of a number of acts that comprised the National Energy Act of 1978, requires not just the utilities in California, but indeed the utilities around the country have to hook up with small power producers and have to buy the power back at a rate that is fair and equitable. We know that the potential utility barrier has been removed. The tax credits are there, so the economics are attractive.

The question is, how do we take the technology from where it is today to start to penetrate that marketplace.

Senator MATSUNAGA. The act of 1978?

Mr. WOLFF. The Public Utility Regulatory Policies Act was one piece of the National Energy Act. Title I has to do with rate design. Sections 201 and 210 is called the Cogeneration of Small Power Producers Act. What it does is exempt power producers under 80 megawatts in capacity from the provisions of the Public Utility Holding Act of 1935, whatever that is, and it requires utilties to hook up and requires them to charge a rate that is fair and equitable.

The Federal Energy Regulatory Commission released a few weeks ago regulations that interpret that "fair and equitable" provision of the legislation, and they suggest that fair and equitable means that the utilities have to buy power back based on their avoided cost or their marginal cost. That is a tremendous incentive and I don't think everyone fully appreciates the impact that would have on utility expansion plans. All the economic benefits of adding new capacity rests equally with the user as well as the utility now, which is to say that the example you cite in California is applicable nationally.

But removing that potential utility barrier, removing the barrier of the high cost which you have done through the windfall profits tax credits, doesn't get us—how do we get from here to there, is the question, and that is what we have tried to address.

Senator **Matsunaga**. As I understand it, while these would apply to interstate utilities, they would not apply to intrastate utilities. If we should encourage the local State legislatures to follow suit and provide laws which would require the use or the purchase of power from these small-scale wind energy systems, would this help?

Mr. **Wolff**. Senator, the way the Federal Energy Regulatory Commission has interpreted the language of the Public Utilities Regulatory Policy Act, is that utilities are required already, and the State public utility commissions have to submit a plan to FERC within 1 year of the issuance of the regulations.

Senator **Matsunaga**. Are they considered to come within the jurisdiction of FERC?

Mr. **Wolff**. Yes. I would be happy to provide the FERC regulations for your consideration.

Senator **Matsunaga**. We would appreciate that. Maybe a little publicity might really help.

You see, we are working in Hawaii, as you would be interested to know, I am sure, on projects in the use of a solar photovoltaic cell. We have been successful on one island, Molokai, in working out an agreement between the homeowner and the Molokai Electric Co. to tie in with the grid so that any excess produced by the solar photovoltaic system in the home will be fed into the system and be bought by the electric company. This was done purely on the basis of an agreement, and had I known about the force of the law—have they come out with a regulation yet?

Mr. **Wolff**. They have.

Senator **Matsunaga**. Oh, it becomes effective next year?

Mr. **Wolff**. The public utility commissions have 1 year to submit, 2 for their implementation plans.

Senator **Matsunaga**. Next year. That might help the situation.

Mr. **Wolff**. Sir, I think it is going to be tremendous, but as long as we seem to be dealing with a recalcitrant Department of Energy that is not able to provide the extra marketplace push to get the technology into the marketplace where further development can take place, we are caught between a rock and a hard place.

Senator MATSUNAGA. Have you noticed any change since the change of the top man in the Department of Energy?

Mr. WOLFF. Well, as Senator Durkin noted, it takes some months to boil minute rice in this town. I think it is too early to tell what is going to happen. There was an excellent article in Energy Daily last week that compared the administration of Mr. Duncan compared to Mr. Schlesinger. They pointed out that the difference was Schlesinger took his energy policy to the White House and Duncan takes his energy policy from the White House.

One of my favorite current rumors is that Mr. Duncan will announce his resignation some time in August and leave after the elections.

I think what we have at the Department of Energy is a management version of musical chairs. Every budget process, you have a different person coming up here.

Senator MATSUNAGA. That has been one of the biggest problems with the Department of Energy; but, personally, I have found a change in the area of acceptance of alternative sources of energy, and for that I am very much pleased.

Mr. WOLFF. Yes. We don't have Mr. O'Leary running around the country suggesting there is no hope for solar energy until 2020.

Senator MATSUNAGA. Thank you, Mr. Wolff.

I believe that is all the time we have for this morning. I do not know whether there are other witnesses waiting or not. Are there other witnesses here waiting to testify?

If not, we will go into recess until the hour of 2 p.m.

[Whereupon, at 12:22 p.m., the hearing was recessed, to reconvene at 2 p.m.]

AFTERNOON SESSION

Senator MATSUNAGA. The subcommittee will come to order.

I must apologize. We just had a vote on the floor as I was headed this way, so that accounts for my tardiness. Our next panel of witnesses consists of Dr. Harold Agnew, president, General Atomic Co., San Diego, Calif.; Dr. Vincent Boyer, senior vice president, Philadelphia Electric Co.; and Mr. Ralph M. Davis, past chairman, Puget Sound Power & Light Co., Bellevue, Wash.

Dr. Agnew, as I understand it, you will testify for 10 minutes, Dr. Boyer for 5 minutes, and Mr. Davis for 5 minutes, and then open yourselves up for questions.

You may proceed, Dr. Agnew.

STATEMENT OF DR. HAROLD M. AGNEW, PRESIDENT, GENERAL ATOMIC CO., SAN DIEGO, CALIF.

Dr. AGNEW. Mr. Chairman and members of the subcommittee, I am Harold M. Agnew, president of General Atomic Co. With me today are N. E. Carey and other senior members of the General Atomic staff.

I thank you for this opportunity to testify before you in connection with the Department of Energy fiscal year 1981 budget request for the gas-cooled thermal reactor program, the gas-cooled fast breeder program, and the magnetic confinement fusion program.

In addition to my oral testimony, I request that three detailed documents entitled "Briefing—National and International HTGR

Program," "Briefing—Gas Cooled Fast Reactor (GCFR) Program," and "General Atomic Fusion Program" be submitted for the record.

Senator **Matsunaga**. Without objection, so ordered.

Dr. **Agnew**. Both gas-cooled reactor programs are being terminated in the administration's fiscal year 1981 budget. I believe it essential to our national energy efforts that these programs be restored.

The recent events in Iran should serve to heighten the importance of expanding rather than curtailing our domestic energy options. The gas-cooled reactor funding level in the current fiscal year represents only a small portion of the total U.S. nuclear budget, but yet these programs offer the potential to make a significant and timely contribution to our future energy requirements.

We continue to support the development of the high temperature gas-cooled reactor (HTGR), and we were very pleased last Wednesday, March 26, when the House Energy Research and Production Subcommittee authorized a fiscal year 1981 funding level of $46.5 million for the HTGR and $3.5 million for the HTGR fuel recycle program.

The HTGR is a high efficiency advanced converter reactor which gets much better energy utilization per pound of uranium than the current generation reactors. We view it as a reactor which has the inherent capability to provide a very high level of public safety, as well as a low risk of loss of the plant owner's investment in the event of plant malfunctions.

The HTGR can provide siting flexibility through its dry cooling capability, which will be of great significance in water-limited areas of the country, especially to fulfill future remote siting requirements. And, the HTGR is unique among nuclear systems in having the potential to provide the high temperatures required for important industrial process heat requirements.

General Atomic has been the leader in the worldwide development of HTGR's since 1957. We have built the 40 MW(e) Peach Bottom prototype HTGR and the 300 MW(e) Fort St. Vrain demonstration HTGR.

I think, Mr. Chairman, it might be of special interest to you if you knew that one of the leaders in these developments was the scientist, Dr. Ed Creutz, who is presently the director of the Buy Shop Museum in Honolulu. He was one of the leaders in this technology and is a strong believer in this as a future option.

The total U.S. investment to date in thermal gas reactors is about $1.3 billion, of which about 70 percent has come from the private sector.

The HTGR program is supported by both the electric utility industry and the process industries, which represent the ultimate users of the technology. This support is directed through two industry groups, Gas Cooled Reactor Associates (GCRA), which represents utilities with about 25 percent of the United States generating capacity, and the HTGR process heat users group, which represents 11 major companies in the steel, coal, chemical, gas, and glass industries.

The Congress has provided excellent support and leadership for these programs in the past. As recently as last November, a House subcommittee informed the Department of Energy of its intention to review fiscal year 1981 funding to accelerate development of an advanced HTGR demonstration plant, and during last week's markup, the subcommittee reaffirmed its commitment to direct the Secretary of DOE to determine an advanced HTGR demonstration plant.

During fiscal year 1980, the major emphasis is on developing and assessing the project alternatives requested by the House Science and Technology Subcommittee on Energy Research and Production.

We believe that the program currently underway will permit a recommendation on a near-term project to be made at the end of fiscal year 1980. The next step would be to initiate a conceptual design and licensing activity in fiscal year 1981. These milestones could lead to project authorization in fiscal year 1982 and 1983.

The fiscal year 1980 budget outlay for the HTGR is $36 million. This includes the $25 million appropriated by Congress last year, together with additional carryover funding to accomplish closeout of steam-cycle program activities. We believe it essential that the fiscal year 1981 HTGR appropriation be increased to $55 million in order to provide a reasonable basis for near-term project authorization.

There is a large international HTGR program in Europe which is closely linked to the U.S. program through government and industrial agreements. The German HTGR program is funded at about $220 million this year, and their total investment to date in HTGR development has been over $1.3 billion.

A closeout of the U.S. program would not be supportive of our intentions in these agreements. There is also a rapidly growing HTGR program in Japan, where there is great interest in cooperation with the United States.

We believe that the program for HTGR spent-fuel treatment must be maintained at least at the current level of capability since this technology is essential to the full application of a low-enriched uranium-thorium fuel cycle. We are continuing to work with Oak Ridge National Laboratory, and to cooperate closely with the strong German program.

Regrettably, the administration has also proposed termination of this program in fiscal year 1981. We urge the Congress to restore funding to a $5 million level in fiscal year 1981. This is essentially the same level as in fiscal year 1980, although it is still only 60 percent of the fiscal year 1979 level.

General Atomic continues to strongly support the gas-cooled fast breeder reactor (GCFR) despite the administration's recommendation to terminate the program in fiscal year 1981. We were very disappointed when, by a close vote, the House energy Research and Production Subcommittee did not provide fiscal year 1981 funding for this program during its March 26 markup of the fiscal year 1981 DOE budget.

The GCFR program has been supported by the U.S. Government, a major segment of the U.S. utility industry through Helium Breeder Associates (HBA), the several European governments for over 15 years. We wish to thank the Congress for their support over this time.

The broad support for the GCFR derives from the potential technical advantages of this unique breeder concept. First is its high breeding performance which significantly exceeds that of other breeder types.

Second is its promise for low capital cost. Third are its excellent inherent and engineered safety features.

Finally, there are distinct operational advantages.

General Atomic recommends that the funding level for GCFR development be maintained at $26 million in the fiscal year 1981 budget. This level will stretch out the current development phase, but will continue to provide the important technological output required for a future decision on proceeding to a demonstration project. This level would also sustain interest by the utility industry and encourage continued collaboration by the international community.

We believe that breeders will one day play a key role in the energy picture in the United States and that to pursue only the liquid metal breeder option while totally abandoning the gas-cooled fast-reactor technology would not be in the national interest.

The funding required to maintain the GCFR as a viable breeder option is relatively inexpensive since the program builds on technology already developed or under development in the LMFBR and HTGR programs.

We believe that when the time for significant breeder deployment arrives, the United States will profit greatly from having maintained a technological capability in the gas-cooled fast-reactor system.

I would now like to comment briefly on General Atomic's fusion program, which includes the highly successful Doublet III experiment. Several important developnents have occurred in the past year.

Doublet III, the largest operating tokamak in the world, represents a new level of sophistication in fusion devices. It has demonstrated currents as high as 2.2 million amps, a new record for tokamaks, and it routinely generates both dee and doublet shaped plasmas with good confinement properties.

In August of 1979 an agreement establishing a 5-year cooperative research program between the Japanese Atomic Energy Research Institute and the U.S. Department of Energy was signed as part of the United States-Japan international cooperative agreement on energy.

The joint effort will result in expenditures of $60 million by JAERI to upgrade the Doublet III machine, with Japanese scientists participating in fusion experiments. Today the physicists of the two nations are working together in San Diego to enhance the capabilities and progress of both nations.

That cooperative agreement is going very well. We have onboard 10 very excellent first-class Japanese physicists working on this program and more are coming in the next phase when the upgrading takes place.

Mr. Chairman, in closing, I believe that in view of the changes which have taken place in the United States during the past few years in the energy supply situation, the vital and unique role which can be fulfilled by gas-cooled reactors has never been more clearly defined.

It is with this in mind that I urge you to adopt our recommendations of $55 million for the HTGR program, $5 million for HTGR spent fuel treatment, and $26 million for the GCFR program.

That concludes my prepared statement and I would now welcome any questions.

Senator **Matsunaga**. Thank you, Dr. Agnew.

[The prepared statement of Dr. Agnew follows:]

STATEMENT BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

U. S. SENATE

FY'81 DEPARTMENT OF ENERGY AUTHORIZATION

HIGH TEMPERATURE GAS COOLED REACTOR

GAS COOLED FAST REACTOR

MAGNETIC FUSION PROGRAM

APRIL 1, 1980

HAROLD M. AGNEW, PRESIDENT

GENERAL ATOMIC COMPANY

SUMMARY - BUDGET RECOMMENDATIONS

Department of Energy

	FY'81 Recommendation
High Temperature Gas Cooled Reactor	$55M
HTGR Fuel Recycle	5M
Gas Cooled Fast Breeder Reactor	26M
Doublet III	15.1M

Mr. Chairman and Members of the Subcommittee, I am Harold M. Agnew, President of General Atomic Company. With me today are N. E. Carey and other senior members of the General Atomic staff. I thank you for this opportunity to testify before you in connection with the Department of Energy FY 1981 budget request for the Gas-Cooled Thermal Reactor Program, the Gas-Cooled Fast Breeder Program, and the Magnetic Confinement Fusion Program. In addition to my oral testimony, I request that three detailed documents entitled Briefing - National & International HTGR Program, Briefing - Gas Cooled Fast Reactor (GCFR) Program, and General Atomic Fusion Program be submitted for the record.

Both gas-cooled reactor programs are being terminated in the Administration's FY 1981 budget. I believe it essential to our national energy efforts that these programs be restored. The recent events in Iran should serve to heighten the importance of expanding rather than curtailing our domestic energy options. The gas-cooled reactor funding level in the current fiscal year represents only a small portion of the total U.S. nuclear budget, but yet these programs offer the potential to make a significant and timely contribution to our future energy requirements.

We continue to support the development of the High Temperature Gas-Cooled Reactor (HTGR), and we were very pleased last Wednesday, March 26, when the House Energy Research and Production Subcommittee authorized a fiscal year 1981 funding level of $46.5M for the HTGR and $3.5M for the HTGR fuel recycle program. The HTGR is a high efficiency advanced converter reactor which gets much better energy utilization per pound of uranium than the current generation reactors. We view it as a reactor which has the inherent capability to provide a very high level of public safety, as well as a low risk of loss of the plant owner's investment in the event of plant malfunctions. The HTGR can provide siting flexibility through its dry cooling capability, which will be of great significance in water-limited areas of the country. And, the HTGR is unique among nuclear systems in having the potential to provide the high temperatures required for important industrial process heat requirements.

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The Congress has provided excellent support and leadership for these programs in the past. As recently as last November, a House Subcommittee informed the Department of Energy of its intention to review FY 1981 funding to accelerate development of an advanced HTGR demonstration plant, and during last week's markup, the Subcommittee reaffirmed its commitment to direct the Secretary of DOE to determine an advanced HTGR demonstration plant.

During FY 1980, the major emphasis is on developing and assessing the project alternatives requested by the House Science and Technology Subcommittee on Energy Research and Production. We believe that the program currently under way will permit a recommendation on a near term project to be made at the end of FY 1980. The next step would be to initiate a conceptual design and licensing activity in FY 1981. These milestones could lead to project authorization in FY 1982 and 1983.

The FY 1980 budget outlay for the HTGR is $36 million. This includes the $25 million appropriated by the Congress last year, together with additional carryover funding to accomplish closeout of steam cycle program activities. We believe it essential that the FY 1981 HTGR appropriation be increased to $55 million in order to provide a reasonable basis for near-term project authorization.

There is a large international HTGR program in Europe which is closely linked to the U.S. program through government and industrial agreements. The German HTGR program is funded at about $220 million this year, and their total investment to date in HTGR development has been over $1.3 billion. A closeout of the U.S. program would not be supportive of our intentions in these agreements. There is also a rapidly growing HTGR program in Japan, where there is great interest in cooperation with the U.S.

In the area of HTGR spent fuel treatment, General Atomic believes that the program must be maintained at least at the current level of capability since this technology is essential to the full application of a low-enriched uranium-thorium fuel cycle. We are continuing to work with Oak Ridge National Laboratory, and to cooperate closely with the strong German program. Regrettably, the Administration has also proposed termination of this program in FY 1981. We urge the Congress to restore funding to a $5.0 million level in FY 1981. This is essentially the same level as in FY 1980, although it is still only 60% of the FY 1979 level.

General Atomic continues to support the Gas Cooled Fast Breeder Reactor (GCFR) despite the Administration's recommendation to terminate the program in FY 1981. We were very disappointed when, by a close vote, the House Energy Research and Production Subcommittee did not provide FY'81 funding for this program during its March 26 markup of the FY'81 DOE budget. The GCFR program has been supported by the U.S. Government, a major segment of the U.S. utility industry through Helium Breeder

Associates (HBA), and several European governments for over 15 years. We wish to thank the Congress for their support over this time.

The broad support for the GCFR derives from the potential technical advantages of this unique breeder concept. First is its high breeding performance which significantly exceeds that of other breeder types. Second is its promise for low capital cost. Third are the inherent and engineered safety features, which provide a level of safety more than adequate for the protection of the public. Finally, there are operational advantages.

General Atomic recommends that the funding level for GCFR development be maintained at $26 million in the FY 1981 budget. This level will stretch out the current development phase, but will continue to provide the important technological output required for a future decision on proceeding to a demonstration project. This level would also sustain interest by the utility industry and encourage continued collaboration by the international community.

We believe that breeders will one day play a key role in the energy picture in the United States. The funding required to maintain the GCFR as a viable breeder option is relatively inexpensive since the program builds on technology already developed or under development in the LMFBR and HTGR programs. We believe that when the time for significant breeder deployment arrives, the U.S. will profit greatly from having breeder options available and leaving the choice to the marketplace. We are confident that the GCFR, given your continued support, will be a desirable option at that time.

I would now like to comment briefly on General Atomic's fusion program, which includes the highly successful Doublet III experiment. Several important developments have occurred in the past year. Doublet III, the largest operating tokamak in the world, represents a new level of sophistication in fusion devices. It has demonstrated currents as high as 2.2 million amps, a new record for tokamaks, and it routinely generates both dee and doublet shaped plasmas with good confinement properties.

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Mr. Chairman, in closing, I believe that with the changes which have taken place in the United States during the past few years in the energy supply situation, the vital and unique role which can be fulfilled by gas-cooled reactors has never been more clearly defined. It is with this in mind that I urge you to adopt our recommendations of $55 million for the HTGR program, $5 million for HTGR spent fuel treatment, and $26 million for the GCFR program.

That concludes my prepared statement and I would now welcome any questions.

BRIEFING
NATIONAL & INTERNATIONAL HTGR PROGRAM

PREPARED AS BACKGROUND FOR THE FY-81 BUDGET CONSIDERATIONS

GENERAL ATOMIC

PREFACE

THIS BRIEFING HAS BEEN PREPARED AS SOURCE MATERIAL FOR THE CURRENT DELIBERATIONS ON THE FY-81 NUCLEAR PROGRAM BUDGET BY THE UNITED STATES CONGRESS. THE PROGRAM PARTICIPANTS (INCLUDING THE UTILITY AND PROCESS INDUSTRIES & THE SUPPLIER INDUSTRY) FIRMLY BELIEVE THAT U.S. GOVERNMENT SUPPORT FOR THE HIGH TEMPERATURE GAS COOLED REACTOR (HTGR) PROGRAM DESERVES A HIGH PRIORITY TO ENSURE REALIZING THE UNIQUE BENEFITS OF THE HTGR TO THE NATIONAL ENERGY PROGRAM. THE PRIME FOCUS OF THE RECOMMENDED FY-81 PROGRAM WILL BE THE CONCEPTUAL DESIGN OF THE HTGR PLANT SELECTED FOR DEMONSTRATION IN FY-80.

CONTENTS

MULTIPURPOSE ROLES OF THE HTGR 1

HTGR SYSTEMS 2
  - HTGR-STEAM ELECTRIC/COGENERATION
  - HTGR-GAS TURBINE ELECTRIC/COGENERATION
  - HTGR -PROCESS HEAT

SAFETY 3

FUEL CYCLE & RESOURCES 4

TECHNOLOGY BACKGROUND 5

PROGRAM SUPPORT 6

PROGRAM DESCRIPTION 7

MULTIPURPOSE ROLES OF HTGR

1

FAMILY OF HIGH EFFICIENCY, ADVANCED CONVERTERS WITH UNIQUE HIGH TEMPERATURE CAPABILITY APPLICABLE TO–

- HIGH EFFICIENCY (40%) ELECTRICITY PRODUCTION
- COGENERATION OF SUPERHEATED STEAM & ELECTRICITY
- "WATERLESS" ELECTRICITY GENERATION FOR ARID SITES, RESTRICTED WATER AREAS
- HIGH TEMPERATURE PROCESS HEAT
- THERMOCHEMICAL HEAT STORAGE AND TRANSPORTATION

HIGH TEMPERATURE PROCESS HEAT

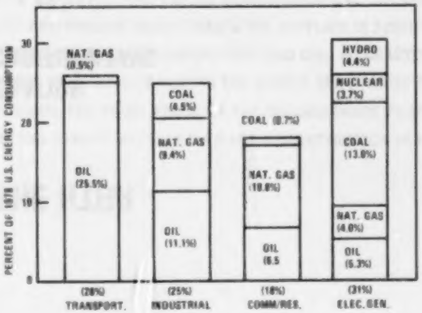
- ONLY REACTOR THAT CAN MEET INDUSTRIAL HIGH TEMPERATURE PROCESS HEAT APPLICATIONS FOR USE IN SYNFUEL PRODUCTION, HYDROGEN PRODUCTION, STEEL MAKING, ETC.

1000°F PROCESS STEAM

- ONLY REACTOR THAT CAN PRODUCE 1000°F PROCESS STEAM FOR INDUSTRIAL USE

CAN DISPLACE/SUPPLEMENT FOSSEL FUELS IN NON-ELECTRIC AREAS

- UNLIKE OTHER NUCLEAR SYSTEMS, IN ADDITION TO ELECTRIC POWER PRODUCTION, HTGR CAN MAKE BROAD CONTRIBUTION TO DISPLACEMENT OF, OR INCREASED PRODUCTION OF, FUELS FOR USE IN NON-ELECTRIC AREAS OF ENERGY CONSUMPTION WHICH REPRESENTED ALMOST 70% OF TOTAL U.S. ENERGY USE IN 1978



ADDITIONAL HTGR DEVELOPMENT INCENTIVES

ENHANCED SAFETY

- INHERENT FEATURES RESULT IN MINIMAL PUBLIC & INVESTMENT RISK

EXTENSION OF U_3O_8 RESOURCES

- COMPARED TO LWR'S REQUIRES ALMOST 25% LESS FOR ONCE THROUGH CYCLE & NEARLY 50% LESS WITH RECYCLE
- OVER PLANT LIFE A SINGLE LARGE HTGR USES 2000 TONS LESS U_3O_8 THAN LWR

HTGR UNIQUELY ADAPTABLE TO EVOLVING NATIONAL POLICY ON PROLIFERATION

- CURRENT PROGRAM BASED ON PROLIFERATION RESISTANT LEU *CYCLE
- CAN ALSO USE DENATURED URANIUM THORIUM FUEL CYCLE OR HEU +CYCLE
- CHANGES IN FUEL CYCLE DO NOT AFFECT PLANT DESIGN

REDUCED RADIATION EXPOSURE OF OPERATION & MAINTENANCE PERSONNEL

- [AT FORT ST. VRAIN] "...THE EXPOSURE RATES HAVE BEEN SO LOW WE CANNOT SUPPLY THE EXPOSURE DATA NRC WANTS"

F.L. SWART
NUCLEAR PROJECT MANAGER
PUBLIC SERVICE COMPANY OF COLORADO

ENVIRONMENTAL ADVANTAGES

- GASEOUS, LIQUID AND SOLID WASTES LOWEST IN NUCLEAR INDUSTRY

A SYMBYOTIC RELATIONSHIP WHEN OPERATING IN CONCERT WITH FAST BREEDER REACTORS

- BECAUSE OF HIGH CONVERSION RATIO (UP TO 0.80) MINIMIZES REQUIREMENT FOR FBRs

*LOW ENRICHED URANIUM

+HIGH ENRICHED URANIUM

HIGH TECHNOLOGY TRANSFER BETWEEN HTGR SYSTEMS

- DEVELOPMENT OF ONE HTGR SYSTEM CONTRIBUTES TO THE DEVELOPMENT OF ALL HTGRs

- THE BULK (~85%) OF HTGR PROGRAMS ARE APPLIED TO GENERIC DESIGN AND TECHNOLOGY DEVELOPMENT THAT IS APPLICABLE TO ALL APPLICATIONS. TYPICAL AREAS OF COMMON TECHNOLOGY ARE:

  –MATERIALS DEVELOPMENT

  –COMPONENT PROCESS DEVELOPMENT/MANUFACTURING

  –FUEL PROCESS DEVELOPMENT/MANUFACTURING

  –SYSTEMS ENGINEERING

  –CODES AND STANDARDS DEVELOPMENT

- FUNDAMENTAL DESIGN AND FABRICATION TECHNOLOGIES ESSENTIALLY THE SAME FOR 80% OF TOTAL BASE COST IN ANY PROJECT UNDER CONSIDERATION

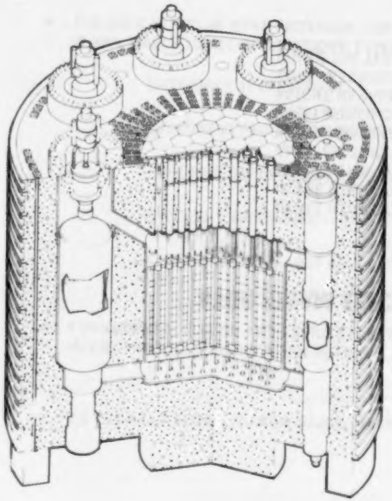
- U.S. PROGRAM BENEFITS FROM MAJOR ON-GOING INTERNATIONAL PROGRAMS e.g., GERMANY, JAPAN, SWITZERLAND, FRANCE

HTGR-STEAM ELECTRIC/COGENERATION

IN ALL HTGR SYSTEMS, HELIUM GAS IS USED AS THE COOLANT TO REMOVE THE HEAT FROM THE CORE. IN THE HTGR-STEAM/ELECTRIC COGENERATION SYSTEM THE HELIUM IS HEATED TO 750-800°C (1382-1472°F). THIS HEAT IS TRANSFERRED IN A HEAT EXCHANGER TO GENERATE STEAM FOR PROCESS USE AND ELECTRICITY PRODUCTION. THE ENTIRE PRIMARY SYSTEM INCLUDING STEAM GENERATOR, HELIUM CIRCULATORS, AND AUXILIARY HEAT EXCHANGERS ARE HOUSED WITHIN THE THICKWALLED PRESTRESSED CONCRETE REACTOR VESSEL. THE URANIUM-THORIUM FUEL IS CONTAINED IN TABLE HEIGHT HEXAGONAL GRAPHITE BLOCKS, SEVERAL THOUSAND OF WHICH MAKE UP THE REACTOR CORE. BECAUSE OF THE HIGH TEMPERATURES, SUPERHEATED STEAM CAN BE PRODUCED, CONTRIBUTING TO THE THERMAL EFFICIENCY OF ABOUT 40%, THE HIGHEST OF ANY NUCLEAR PLANT.

HTGR SYSTEMS

HTGR-STEAM ELECTRIC/COGENERATION



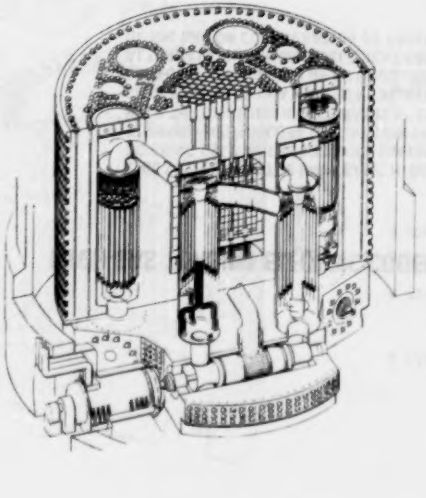
- 40% EFFICIENT ELECTRICITY PRODUCER
- 1000°F STEAM CAN DISPLACE COAL, OIL AND GAS IN PROCESS INDUSTRY
- USES 25% LESS WATER THAN LWR
- NEAREST TERM OPTION
- CURRENT FOCUS OF GERMAN PROGRAM

HTGR-GAS TURBINE ELECTRIC/COGENERATION

THIS SYSTEM USES THE SAME BASIC HTGR TECHNOLOGY. EXCEPT THAT THE HELIUM, IN ADDITION TO BEING USED AS THE COOLANT, IS ALSO USED AS THE WORKING FLUID WITH AN INTEGRATED GAS TURBINE. HELIUM CORE OUTLET TEMPERATURES ARE HIGHER, IN THE 800-850^{0}C (1472-1562^{0}F) RANGE. WITH THE GAS TURBINE, A "BRAYTON" CYCLE IS USED WHICH, IN ADDITION TO HIGH THERMAL EFFICIENCY, RESULTS IN A HIGH HEAT REJECTION TEMPERATURE (150^{0}C/~300^{0}F) THIS RESULTS IN THE ECONOMIC APPLICATION OF DRY COOLING FOR "WATERLESS" ELECTRIC POWER GENERATION. AS AN ALTERNATE, THIS HIGH REJECT HEAT CAN BE USED IN A "BOTTOMING" CYCLE TO ACHIEVE EFFICIENCIES OF 50% OR FOR COGENERATION OF PROCESS STEAM.

HTGR SYSTEMS

HTGR-GAS TURBINE ELECTRIC/COGENERATION



- 40% EFFICIENT ELECTRICITY PRODUCER
- 50% EFFICIENCY WITH A BOTTOMING CYCLE
- "WATERLESS" POWER GENERATION
  - –ECONOMICAL DRY COOLING FOR ARID AND WATER RESTRICTED AREAS
  - –SITING FLEXIBILITY
- HIGH WASTE HEAT REJECTION TEMPERATURE (150°C/~300°F) SUITED TO INTERMEDIATE TEMPERATURE COGENERATION
- BENEFITS FROM COOPERATIVE INTERNATIONAL PROGRAM WITH GERMANY

HTGR-PROCESS HEAT

PROCESS HEAT/REFORMING

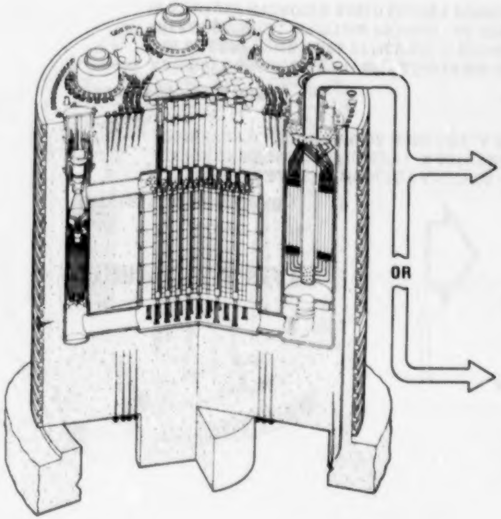
UTILIZES SAME BASIC TECHNOLOGY AS OTHER HTGR SYSTEMS. WITH HELIUM CORE OUTLET TEMPERATURES OF 800-850°C (1472-1562°F), A REFORMER CAN BE USED TO REACT STEAM AND METHANE TO FORM HYDROGEN AND CARBON MONOXIDE, A REDUCING GAS.

ADVANCED APPLICATIONS

AT HIGHER CORE OUTLET TEMPERATURES 850-1000°C (1562-1832°F) THIS REFORMING REACTION CAN BE DONE MUCH MORE EFFICIENTLY. HYDROGEN CAN BE PRODUCED FROM WATER THROUGH A THERMOCHEMICAL SPLITTING PROCESS - AN APPLICATION THAT WOULD HAVE GREAT SIGNIFICANCE IN A FUTURE HYDROGEN BASED ENERGY ECONOMY.

HTGR SYSTEMS

HTGR-PROCESS HEAT



- ONLY NUCLEAR HEAT SOURCE WHICH CAN SUBSTITUTE FOR FOSSIL FUELS IN MANY HIGH TEMPERATURE INDUSTRIAL APPLICATIONS
- CAN EXTEND FOSSIL RESOURCE USAGE FOR SYNTHETIC FUEL PRODUCTION BY 30-40%

TO REFORMER TO PRODUCE REDUCING GAS FOR:
  - –STEEL MAKING
  - –SUBSTITUTE PIPELINE GAS
  - –AMMONIA
  - –METHANOL

TO DIRECT PROCESS EXCHANGER

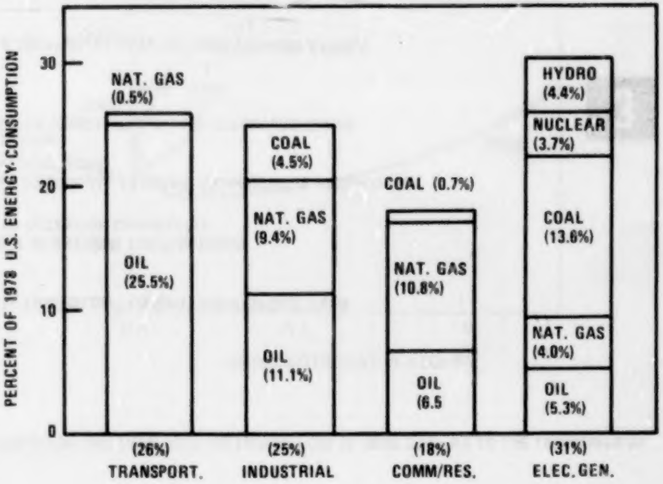
TO PRODUCE HYDROGEN BY
  - –THERMOCHEMICAL WATER SPLITTING

- BENEFITS FROM COOPERATIVE INTERNATIONAL PROGRAMS (GERMANY, JAPAN)

HTGR SYSTEMS

RESPONSIVE TO TOMORROWS ENERGY NEEDS

HTGR SYSTEMS CAN EVOLVE TO MEET EVER BROADER NEEDS IN MANY ENERGY INTENSIVE PROCESSES AND CAN HELP SAFEGUARD ENERGY SUPPLIES BY DISPLACING FOSSIL FUELS FOR ELECTRICITY PRODUCTION FOR PROCESS HEAT IN THE COMMERCIAL AND INDUSTRIAL SECTOR, AND CONTRIBUTE TO THE PRODUCTION OF SYNTHETIC FUELS



SAFETY

BASED ON INHERENT CHARACTERISTICS

- MASSIVE (3 MILLION POUNDS+) GRAPHITE CORE (SLOW TEMPERATURE RESPONSE EVEN IF COOLANT CIRCULATION STOPS)
- GRAPHITE CORE & CERAMIC FUEL STABLE TO EXTREME TEMPERATURES (RETAINS INTEGRITY & FISSION PRODUCT RETENTION CAPABILITY)
- GASEOUS HELIUM COOLANT (IMPOSSIBLE TO LOSE ALL COOLANT; UNAMBIGUOUS INDICATIONS OF COOLANT CONDITIONS; NO CHEMICAL REACTIONS)
- MASSIVE PRESTRESSED CONCRETE REACTOR VESSEL (REDUNDANT STRUCTURE MAKES CATASTROPHIC FAILURE INCREDIBLE)
- INHERENT SHUTDOWN MECHANISMS
  (LARGE CORE NEGATIVE TEMPERATURE COEFFICIENT DOES NOT REQUIRE FAST ACTING SHUTDOWN SYSTEM)

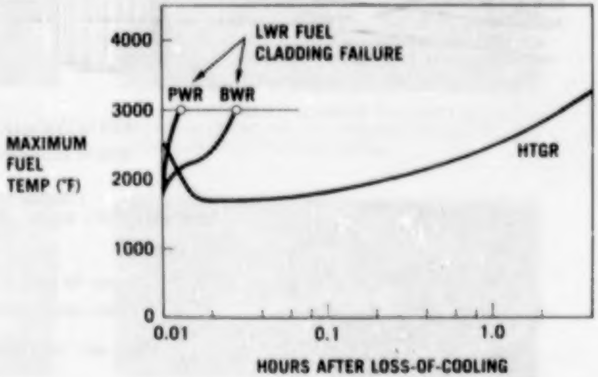
INHERENT FEATURES SUPPLEMENTED WITH ENGINEERED SAFETY SYSTEMS

- INDEPENDENT AUXILIARY COOLING SYSTEM
- INDEPENDENT EMERGENCY REACTIVITY SHUTDOWN SYSTEM
- REACTOR CONTAINMENT BUILDING

SAFETY

TIME TO RESPOND

SUBSTANTIAL TIME (1-2 HRS) AVAILABLE TO EVALUATE AND RESPOND WITH CORRECTIVE ACTION PRIOR TO ONSET OF PHYSICAL DAMAGE TO THE PLANT INVESTMENT



SUBSTANTIAL TIME (10-20 HRS) AVAILABLE FOLLOWING LOSS OF CORE COOLING TO THE THRESHOLD OF FUEL FAILURE

FUEL CYCLE & RESOURCE CONSERVATION

LOW ENRICHED URANIUM (LEU)/THORIUM FUEL CYCLE

- 20% ENRICHED U NOT USABLE FOR WEAPONS
- Pu PRODUCTION ABOUT 1/3 THAT FROM NORMAL LWR CYCLE

FUEL CYCLE COST ADVANTAGE UNDER COMPARABLE CONDITIONS

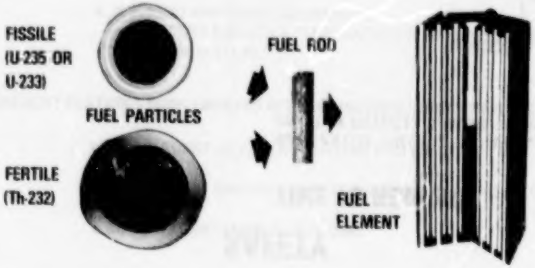
- COST BENEFITS INCREASE WITH INCREASING U_3O_8 COSTS

EXTENDS U_3O_8 RESOURCE BASE

- 25 to 50% REDUCTIONS FROM LWR DEPENDING ON FUEL CYCLE MODE
- SIGNIFICANT EXTENSION OF RESOURCES POSSIBLE

FLEXIBLE FUEL CYCLE WITHIN EXISTING PLANT AND CORE DESIGN

- CHANGES IN FUEL CYCLE DO NOT AFFECT PLANT DESIGN



HTGR FUEL IS MADE UP OF TINY BEAD - LIFE PARTICLES OF URANIUM AND OF THORIUM, EACH OF WHICH IS COATED WITH PYROCARBON MATERIALS. THESE PARTICLES ARE MIXED AND CAST INTO FINGER - SIZED RODS, AND THE RODS ARE SEALED INTO FUEL CAVITIES RUNNING VERTICALLY THROUGH TABLE HEIGHT HEXAGONAL GRAPHITE BLOCKS. THE ACTIVE CORE CONSISTS OF A CLOSE - FITTING MASS OF THESE GRAPHITE BLOCKS THROUGH WHICH THE HELIUM COOLANT FLOWS IN VERTICAL CHANNELS

ALL HTGR SYSTEMS USE COMMON FUEL TECHNOLOGY

TECHNOLOGY BACKGROUND

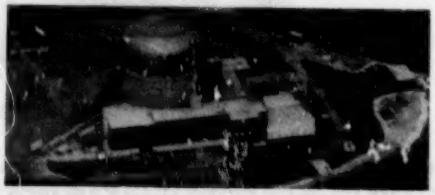
UNITED STATES

A SUBSTANTIAL EXPERIENCE & TECHNOLOGY CURRENTLY EXISTS IN THE U.S.

HTGR TEST FACILITY COMPOUND, INCLUDING AIR FLOW TEST FACILITY, COMPONENT TEST TOWER, PCRV MODELS, TENDON TEST FACILITY, PCRV WIRE WINDING MACHINE AND HELIUM CIRCULATOR TEST FACILITY.

COMPLETE FUEL MANUFACTURING FACILITIES FOR COATING PARTICLES AND FUEL ROD PRODUCTION AS WELL AS LOADING OF GRAPHITE FUEL BLOCKS.

THE 300 MW(e) FORT ST. VRAIN HTGR IS NOW UNDERGOING STARTUP TESTING BY THE PUBLIC SERVICE COMPANY OF COLORADO AND HAS OPERATED AT 68% OF FULL POWER TO DATE. IT IS CURRENTLY RESTRICTED TO 70% POWER BY NRC. FULL POWER OPERATION IS PLANNED FOR 1980.



THE 40 MW(e) PEACH BOTTOM UNIT 1 HTGR WAS OPERATED SUCCESSFULLY BY THE PHILADELPHIA ELECTRIC COMPANY FROM 1967 TO 1974, WHEN THE PLANT WAS SHUT DOWN FOR DECOMMISSIONING AFTER COMPLETING THE PLANNED DEMONSTRATION PROGRAM.

TECHNOLOGY BACKGROUND

INTERNATIONAL

A SUBSTANTIAL INTERNATIONAL EXPERIENCE EXISTS ON GAS COOLED REACTOR TECHNOLOGY WHICH SUPPORTS U.S. PROGRAM

1956 – OVER 600 REACTOR YEARS OF OPERATING EXPERIENCE TO DATE ON GAS–COOLED REACTORS IN THE U.K. AND FRANCE

1964 – DRAGON (MULTI-NATIONAL) – FIRST HTGR/HELIUM COOLED/COATED FUEL PARTICLE

1967 – AVR (GERMANY) – FIRST HTGR WITH PEBBLE BED FUEL

DRAGON

330 MW(e) THTR

50 MW(e) HELIUM TURBINE-OBERHAUSEN

HHV HELIUM COMPONENT TEST LOOP

1975 – OBERHAUSEN (GERMANY) – FOSSIL FIRED CLOSED CYCLE HELIUM GAS TURBINE PLANT

1979 – HHV (GERMANY) – TEST LOOP FOR HTGR-GAS TURBINE COMPONENTS

1983 – THTR (GERMANY – ESTIMATED STARTUP 300 MW(e) HTGR WITH PEBBLE BED FUEL

PROGRAM SUPPORT

OVER $2.5 BILLION INVESTMENT IN HTGR TECHNOLOGY

- CUMMULATIVE EXPENDITURES TO DATE/(CURRENT YEAR BUDGET)

UNITED STATES	$1.3 BILLION*/($38 MILLION)
FEDERAL REPUBLIC OF GERMANY	$1.3 BILLION/($220 MILLION)
SWITZERLAND	$35 MILLION/ ($7 MILLION)
FRANCE	$70 MILLION/($1 MILLION)
JAPAN	$100 MILLION/($25 MILLION)

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* ~70% FROM PRIVATE (NON-GOVERNMENT) SOURCES

MECHANISMS IN PLACE FOR INTERNATIONAL COOPERATION ON HTGRs

- "UMBRELLA AGREEMENT" – MULTI-NATIONAL (UNITED STATES, GERMANY) FRANCE, SWITZERLAND) INTER-GOVERNMENT TECHNICAL EXCHANGE AND COOPERATION AGREEMENT ON GCR'S REACHED IN 1977

  –SIMILAR AGREEMENT UNDER DISCUSSION WITH JAPAN

PROGRAM SUPPORT

PROGRAM HAS ELECTRIC UTILITY SUPPORT

- IN 1978 A UTILITY ORGANIZATION, GCRA, WAS FORMED TO PROVIDE SUPPORT AND GUIDANCE TO THE PROGRAM. GCRA UTILITIES CURRENTLY REPRESENT APPROXIMATELY 25% OF THE INSTALLED ELECTRIC GENERATING CAPACITY IN THE UNITED STATES.

- ARIZONA PUBLIC SERVICE COMPANY
- CITY OF TACOMA
- COLORADO-UTE ELECTRIC ASSOCIATION
- DELMARVA POWER & LIGHT COMPANY
- EMPIRE STATE ELECTRIC ENERGY RESEARCH CORP.
  - CENTRAL HUDSON GAS & ELECTRIC CORP.
  - CONSOLIDATED EDISON COMPANY
  - LONG ISLAND LIGHTING COMPANY
  - NEW YORK STATE ELECTRIC & GAS CORP.
  - NIAGARA MOHAWK POWER CORP.
  - ROCHESTER GAS & ELECTRIC CORP.
- FLORIDA POWER & LIGHT COMPANY
- GULF STATES UTILITIES
- IDAHO POWER COMPANY
  - ORANGE & ROCKLAND UTILITIES
- NORTHEAST UTILITIES
  - THE CONNECTICUT LIGHT & POWER COMPANY
  - THE HARTFORD ELECTRIC LIGHT COMPANY
  - WESTERN MASSACHUSETTES ELECTRIC COMPANY
  - HOLYOKE WATER POWER COMPANY
- PACIFIC GAS & ELECTRIC COMPANY
- PACIFIC POWER & LIGHT COMPANY
- PHILADELPHIA ELECTRIC COMPANY
- PUBLIC SERVICE COMPANY OF COLORADO
- PUBLIC SERVICE COMPANY OF NEW MEXICO
- PUGET SOUND POWER & LIGHT COMPANY
- SALT RIVER PROJECT
- SAN DIEGO GAS & ELECTRIC COMPANY
- WASHINGTON PUBLIC POWER SUPPLY SYSTEM
- PUBLIC SERVICE ELECTRIC & GAS COMPANY

IN 1979 A GROUP OF MAJOR INDUSTRIAL FIRMS FORMED A PROCESS HEAT USERS GROUP TO SUPPORT THE CONTINUED DEVELOPMENT OF THE HTGR

- ALLIED CHEMICAL
- AMERICAN NATURAL SERVICE
- ARMCO
- BETHLEHEM STEEL
- CONSOLIDATED NATURAL GAS SERVICE
- GULF SCIENCE & TECHNOLOGY
- INLAND STEEL
- OWENS-CORNING FIBERGLAS
- SCALLOP COAL CORP.
- UNITED GAS PIPE LINE
- UNITED STATES STEEL

FY 80 HTGR PROGRAM DESCRIPTION

IMPLEMENT PROGRAM GUIDANCE FROM COMMITTEE ON SCIENCE AND TECHNOLOGY TO DEPARTMENT OF ENERGY (GUIDANCE LETTER – NOV. 8, 1979) ON DEVELOPING RECOMMENDATION FOR HTGR LEAD PROJECT

EVALUATE PROJECT OPTIONS

- GAS TURBINE FOR ELECTRIC POWER PRODUCTION
- PROCESS HEAT OR COGENERATION OPTIONS
  - PROCESS STEAM/ELECTRICITY COGENERATION
  - PROCESS HEAT/ELECTRICITY COGENERATION
- NUCLEAR HEAT SOURCE DEMONSTRATION PROJECT FOR GAS TURBINE/PROCESS HEAT COMPONENTS

RECOMMEND HTGR LEAD PROJECT

CONTINUE GENERIC DESIGN AND BASE TECHNOLOGY DEVELOPMENT

CONTINUE SPENT FUEL TREATMENT PROGRAM

CONTINUE INTERNATIONAL COOPERATION

FY 1980 NATIONAL PROGRAM FUNDING:

FOR HTGR APPLICATION AND BASE TECHNOLOGY	$38.0 MILLION
FOR SPENT FUEL TREATMENT PROGRAM	$4.5 MILLION

RECOMMENDED FY 81 HTGR PROGRAM DESCRIPTION

UNDERTAKE HTGR LEAD PROJECT ACTIVITIES

- CONCEPTUAL DESIGN
- SCHEDULE AND COST ESTIMATE
- MANAGEMENT PLAN
- SITE REVIEW
- ENVIRONMENTAL IMPACT STATEMENT

ESTABLISH OVERALL HTGR PROGRAM PLAN

CONTINUE BASE TECHNOLOGY, e.g.,

- FUEL/MATERIAL DEVELOPMENT
- CORE DESIGN
- SAFETY AND RELIABILITY

CONTINUE DESIGNS ON FOLLOW-ON APPLICATIONS

CONTINUE SPENT FUEL TREATMENT PROGRAM

CONTINUE INTERNATIONAL COOPERATIVE EFFORTS

RECOMMENDED FY1981 NATIONAL PROGRAM FUNDING:

FOR HTGR PROJECT AND BASE TECHNOLOGY	$55 MILLION
FOR SPENT FUEL TREATMENT PROGRAM	$5 MILLION

BRIEFING
GAS COOLED FAST REACTOR (GCFR) PROGRAM

PREPARED AS BACKGROUND FOR THE FY-81 BUDGET CONSIDERATIONS

GENERAL ATOMIC

PREFACE

THIS DOCUMENT HAS BEEN PREPARED AS BACKGROUND INFORMATION WHICH IT IS HOPED WILL BE OF ASSISTANCE DURING THE 1980 CONGRESSIONAL REVIEW OF THE FISCAL YEAR 1981 BUDGET FOR THE GAS-COOLED FAST REACTOR (GCFR) PROGRAM.

IT IS THE BELIEF OF THE SUPPORTERS OF THE GCFR PROGRAM THAT IF NUCLEAR ENERGY IS TO PROVIDE A SIGNIFICANT PORTION OF U.S. ENERGY NEEDS, THEN A CONTINUATION OF BREEDER REACTOR DEVELOPMENT IS ESSENTIAL TO PROVIDE ASSURANCE OF FUEL SUPPLY. FURTHER, THE GCFR SHOULD BE A PART OF THE NATIONAL BREEDER PROGRAM SO AS TO PROVIDE A TECHNICAL ALTERNATIVE AND ECONOMIC COMPETITION.

CONTENTS

WHY THE GCFR 1

THE GCFR SYSTEM 2

GCFR TECHNOLOGY 3

PROGRAM SUPPORT 4

PROGRAM DESCRIPTION 5

WHY THE GAS COOLED FAST BREEDER (GCFR)

BREEDERS ARE REQUIRED IF FULL USE IS TO BE MADE OF THE ENERGY AVAILABLE FROM OUR URANIUM AND THORIUM RESOURCES.

THE GCFR IS PERCEIVED TO HAVE PERFORMANCE, COST AND OPERATING ADVANTAGES OVER OTHER BREEDER SYSTEMS.

A LARGE SEGMENT (OVER 30%) OF THE UTILITY INDUSTRY SUPPORTS MAINTAINING THE GCFR OPTION.

THE GCFR OPTION IS AFFORDABLE SINCE IT MAKES DIRECT USE OF EXISTING AND ONGOING TECHNOLOGY INVESTMENTS IN THE HIGH TEMPERATURE GAS COOLED REACTOR (HTGR) AND THE LMFBR.

GCFR TECHNICAL AND ECONOMIC INCENTIVES

HIGHEST BREEDING RATIO

THE HELIUM COOLANT DOES NOT INTERACT WITH NEUTRONS. SINCE THE NUCLEAR PERFORMANCE IS NOT DEGRADED, MORE NEUTRONS ARE AVAILABLE FOR BREEDING NEW FUEL.

LOW CAPITAL COSTS

NO REQUIREMENT FOR INTERMEDIATE HEAT TRANSFER LOOPS, DRASTICALLY REDUCED REQUIREMENT FOR STAINLESS STEEL AND SIMPLIFIED AND MORE COMPACT PLANT SYSTEMS.

INHERENT SAFETY FEATURES

NEGATIVE DOPPLER AND POWER COEFFICIENT, A STABLE POWER DISTRIBUTION; A COOLANT NOT SUBJECT TO VOID FORMATION OR COMPLETE LOSS, DOES NOT BECOME RADIOACTIVE.

ENGINEERED SAFETY FEATURES

REDUNDANT AND DIVERSE FORCED COOLING SYSTEMS BACKED BY A CAPABILITY FOR NATURAL CIRCULATION COOLING; MULTIPLE AND DIVERSE SHUTDOWN SYSTEMS; A MASSIVE PRESTRESSED CONCRETE REACTOR VESSEL WHICH ENCLOSES THE ENTIRE HELIUM COOLING SYSTEM AND WHICH HAS REDUNDANCY WHICH MAKES CATASTROPHIC FAILURE INCREDIBLE.

OPERATING AND MAINTENANCE ADVANTAGES

AN INERT, TRANSPARENT, NON-RADIOACTIVE COOLANT PROVIDES EASE OF ACCESSIBILITY FOR MAINTENANCE AND REPAIR; REDUCED RADIATION EXPOSURE LEVELS, CHEMICALLY NON-HAZARDOUS WORKING CONDITIONS.

OTHER INCENTIVES FOR DEVELOPMENT

TECHNICAL AND ECONOMIC ASSURANCE

THE VITAL IMPORTANCE OF THE BREEDER REACTOR TO LONG TERM FISSION ENERGY FUEL SUPPLY REQUIRES A HIGH DEGREE OF ASSURANCE THAT A TECHNICALLY AND ECONOMICALLY SATISFACTORY PRODUCT WILL EMERGE. PRUDENT MANAGEMENT SUPPORTS THE PARALLEL DEVELOPMENT OF TECHNOLOGICALLY DIFFERENT SYSTEMS. THE INCREMENTAL NATURE OF GCFR DEVELOPMENT REQUIREMENTS MAKES THIS APPROACH ECONOMICALLY FEASIBLE.

BENEFIT OF COMPETITION

SYSTEM PERFORMANCE AND COST WILL BE OPTIMIZED AS A RESULT OF ECONOMIC AND TECHNICAL COMPETITION. THROUGH REDUCED COSTS TO UTILITY CUSTOMERS, THE NATION BENEFITS FROM THIS COMPETITION.

THE GCFR SYSTEM

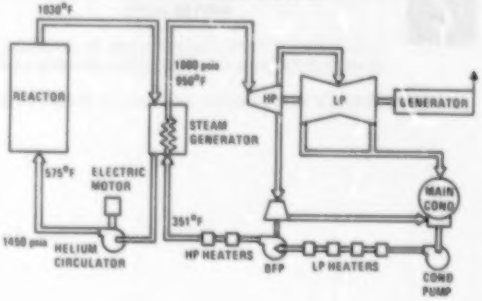
THE GCFR NUCLEAR STEAM SUPPLY SYSTEM IS CHARACTERIZED BY THE MASSIVE PRESTRESSED CONCRETE REACTOR VESSEL WHICH CONTAINS THE HELIUM COOLANT AND THE PRINCIPAL SYSTEM COMPONENTS. THE MULTITUDE OF PRESTRESSING TENDONS, BOTH AXIAL AND CIRCUMFERENTIAL, GIVE STRENGTH TO THE VESSEL IN REDUNDANT FASHION. THE ENTIRE INNER SURFACE IS LINED WITH A STEEL SKIN. THE LARGE CENTRAL CAVITY CONTAINS THE CORE, SUPPORTED FROM UNDERNEATH TO ALLOW FOR UPFLOW COOLING AND NATURAL CIRCULATION. THE HELICALLY-WOUND STEAM GENERATORS AND AUXILIARY HEAT EXCHANGERS ARE LOCATED IN CAVITIES CONNECTED TO THE CENTRAL CAVITY BY DUCTS. THE ENTIRE COOLING CIRCUIT IS FORMED BY THE CAVITIES AND THE DUCTS. THUS THE COOLANT REMAINS WITHIN THE PCRV AT ALL TIMES AND NEVER PASSES THROUGH A PIPE. HELIUM IS CIRCULATED BY THE MAIN CIRCULATOR POWERED BY THE LARGE ELECTRIC MOTOR SHOWN.

THE MAIN LOOP COOLING DIAGRAM ILLUSTRATES THE CONVENTIONAL NATURE OF THE SECONDARY SYSTEMS. FEEDWATER FROM THE HIGH PRESSURE HEATERS PASSES THROUGH THE STEAM GENERATORS WHERE IT BECOMES STEAM AT SUPERHEATED TEMPERATURES. IT PASSES THEN THROUGH A CONVENTIONAL STEAM TURBINE WHICH DRIVES THE ELECTRICAL GENERATOR. THE STEAM IS CONDENSED AND FLOWS TO THE LOW PRESSURE HEATERS AND TURBINE-DRIVEN BOILER FEED PUMP.

THE PRIMARY CIRCUIT IS EXTREMELY SIMPLE. HELIUM PASSES UP THROUGH THE CORE, THROUGH THE UPPER DUCTS AND DOWN THROUGH THE STEAM GENERATORS, IS RECOMPRESSED IN THE CIRCULATORS AND FLOWS BACK TO THE CORE THROUGH THE LOWER DUCTS.

MAIN LOOP COOLING SYSTEM

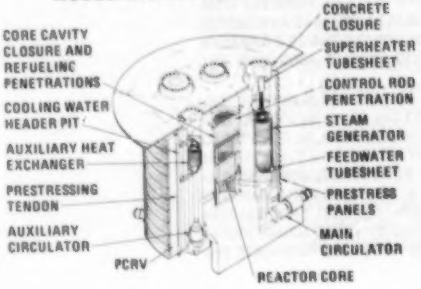
OPERATING CONDITIONS



THE GCFR SYSTEM

2

300 MW(e) GCFR
NUCLEAR STEAM SUPPLY SYSTEM


CONCRETE CLOSURE
SUPERHEATER TUBESHEET
CONTROL ROD PENETRATION
STEAM GENERATOR
FEEDWATER TUBESHEET
PRESTRESS PANELS
MAIN CIRCULATOR
REACTOR CORE
CORE CAVITY CLOSURE AND REFUELING PENETRATIONS
COOLING WATER HEADER PIT
AUXILIARY HEAT EXCHANGER
PRESTRESSING TENDON
AUXILIARY CIRCULATOR
PCRV

THE GAS COOLED FAST REACTOR NUCLEAR STEAM SUPPLY SYSTEM

COOLANT	INERT HELIUM
HIGH BREEDING RATIO	1.4–1.5
REACTOR VESSEL	PRESTRESSED CONCRETE REDUNDANT STRUCTURE
CIRCULATORS	MOTOR DRIVEN RADIAL FLOW
STEAM GENERATORS	HELICAL TUBE ONCE THROUGH

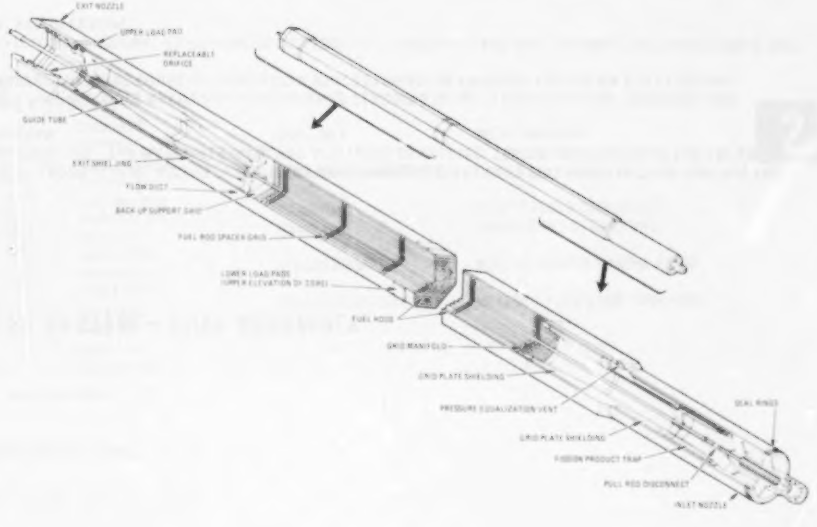
THE GCFR SYSTEM — FUEL ASSEMBLY

THE HEXAGONAL FUEL ASSEMBLY CONTAINS 265 INDIVIDUAL STEEL-CLAD PINS WHICH IN TURN CONTAIN THE NUCLEAR FUEL. THE MATERIALS INVOLVED ARE THOSE DEVELOPED, TESTED AND PROVEN IN THE LMFBR PROGRAM.

GCFR FUEL INCLUDES ARTIFICIALLY ROUGHENED CLADDING SO AS TO ENHANCE HEAT TRANSFER AND A TESTED PRESSURE EQUALIZATION SYSTEM WHICH ELIMINATES PRESSURE FORCES ON THE CLADDING.

PARTIAL GCFR ASSEMBLIES HAVE BEEN SUCCESSFULLY TESTED IN FAST AND THERMAL TEST REACTORS IN THE U.S. AND IN EUROPE.

THE GCFR SYSTEM — FUEL ASSEMBLY


EXIT NOZZLE
UPPER LOAD PAD
REPLACEABLE ORIFICE
GUIDE TUBE
EXIT SHIELDING
FLOW DUCT
BACK UP SUPPORT GRID
FUEL ROD SPACER GRID
LOWER LOAD PADS (UPPER ELEVATION OF CORE)
FUEL RODS
GRID MANIFOLD
GRID PLATE SHIELDING
PRESSURE EQUALIZATION VENT
GRID PLATE SHIELDING
FISSION PRODUCT TRAP
PULL ROD DISCONNECT
INLET NOZZLE
SEAL RINGS

GCFR TECHNOLOGY

THE GCFR DIRECTLY INCORPORATES MANY OF THE SYSTEMS, COMPONENTS AND TECHNOLOGIES WHICH HAVE BEEN DEMONSTRATED OR ARE UNDER DEVELOPMENT IN THE HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR) AND LMFBR PROGRAMS.

HTGR PLANT AND REACTOR SYSTEMS

THE DESIGN OF GCFR PLANT AND REACTOR SYSTEMS DIRECTLY ADOPTS THE TECHNOLOGY WHICH HAS BEEN DEMONSTRATED IN THE FORT ST. VRAIN NUCLEAR GENERATING STATION. (THE LOWER GCFR COOLANT TEMPERATURES PROVIDE LESS DEMANDING ENVIRONMENTAL CONDITIONS.)

- PRESTRESSED CONCRETE REACTOR VESSEL
- HELIUM CIRCULATOR
- STEAM GENERATORS
- THERMAL BARRIER
- HELIUM HANDLING SYSTEMS
- LICENSING PRECEDENTS
- COMPUTATIONAL METHODS

LMFBR FUEL AND SAFETY RELATED TECHNOLOGY

GCFR FUEL ASSEMBLIES ARE DESIGNED TO MAXIMIZE USE OF LMFBR TECHNOLOGY. BY UTILIZING THE SAME MATERIALS, SIMILAR DIMENSIONS AND A PRESSURE EQUALIZATION SYSTEM WHICH ELIMINATES THE EFFECT OF HELIUM PRESSURE, THE ENORMOUS LMFBR FUEL DATA BASE BECOMES APPLICABLE TO THE GCFR.

- IRRADIATION DATA
- MATERIALS PROPERTIES
- REACTOR PHYSICS
- FUEL CHEMISTRY
- SAFETY TECHNOLOGY
- CONTROL ROD DRIVE MECHANISMS

KEY PROOF OF PRINCIPLE EXPERIMENTS COMPLETED

THE GCFR CONCEPT INCORPORATES CERTAIN UNIQUE FEATURES INCLUDING THE USE OF VENTED FUEL WITH ROUGHENED CLADDING AND GRID SPACERS. MAJOR EMPHASIS IN THE DEVELOPMENT PROGRAM HAS BEEN DIRECTED TOWARD DEMONSTRATING THESE UNIQUE FEATURES.

- VENTED FUEL PERFORMANCE – 1971 – AT OAK RIDGE NATIONAL LABORATORY
- ROUGHENED FUEL HEAT TRANSFER – 1972 – SWITZERLAND
- HIGH BREEDING RATIO – 1975 – ARGONNE NATIONAL LABORATORY
- FUEL BUNDLE TEST (IN PILE) – 1977 – MOL, BELGIUM

GCFR TECHNOLOGY

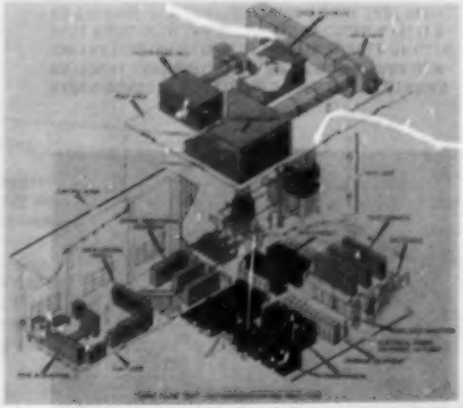
INCREMENTAL DEVELOPMENT COSTS

THROUGH USE OF COMPONENT, FUEL AND SYSTEMS TECHNOLOGY DEVELOPED ON OTHER PROGRAMS, THE DEVELOPMENT REQUIREMENTS FOR THE GCFR ARE DRAMATICALLY REDUCED. PROGRAM EFFORTS CAN BE CONCENTRATED ON THOSE SPECIFIC AREAS WHERE THE DESIGNS OR REQUIREMENTS DIFFER.

GCFR TECHNOLOGY

GCFR CRITICAL
ASSEMBLY EXPERIMENTS
AT
ARGONNE NATIONAL
LABORATORY

THE GCFR SERIES OF CRITICAL ASSEMBLY EXPERIMENTS PERFORMED IN THE ANL ZPR-9 FACILITY SHOWN ABOVE, VERIFIED IMPORTANT SAFETY CHARACTERISTICS OF THE GCFR. THEY ALSO DEMONSTRATED THE ABILITY TO PREDICT THE KEY RATIOS THAT ARE USED IN CALCULATING BREEDING RATIO. THUS THE HIGH BREEDING RATIO OF THE GCFR HAS A DEMONSTRATED EXPERIMENTAL BASIS.



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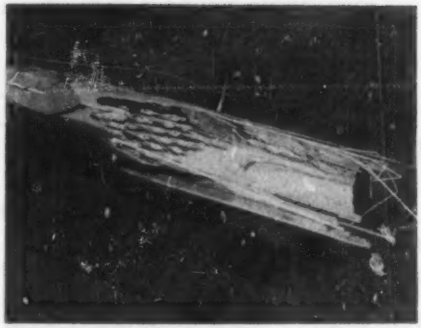
TEST LOOP AT
OAK RIDGE
NATIONAL
LABORATORY

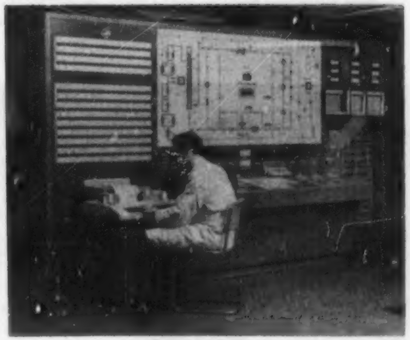
THE CFTL SIMULATES THE BEHAVIOR OF GCFR FUEL ASSEMBLIES AT FULL FLOW, HELIUM PRESSURE AND TEMPERATURE. IT ENABLES STUDY OF ASSEMBLY BEHAVIOR THROUGH ALL NORMAL, TRANSIENT AND SIMULATED ACCIDENT CONDITIONS. THE LOOP IS UNDER CONSTRUCTION, AND IS EXPECTED TO START SHAKEDOWN OPERATION IN OCTOBER 1981.

GCFR TECHNOLOGY



LOW POWER SAFETY
EXPERIMENTS AT
LOS ALAMOS
SCIENTIFIC LABORATORY

THE LPSE, ALREADY UNDER WAY, IS LEADING TO AN UNDERSTANDING OF THE ABILITY OF THE GCFR TO DEAL WITH SHUTDOWN COOLING LOSS. IN ANOTHER PHASE OF THIS FLEXIBLE EXPERIMENT, NATURAL CIRCULATION COOLING IN THE GCFR IS BEING SIMULATED AND STUDIED.



THE GCFR LOOP
IN THE BR-2
REACTOR AT MOL
BELGIUM

EXPERIMENTS IN THIS LOOP, FUNDED BY THE GERMAN NATIONAL LABORATORY AT JUELICH (KFA), ARE DEMONSTRATING OPERATION OF A 12-PIN BUNDLE OF GCFR FUEL RODS. WITH THE EXCEPTION OF USING A FILTERED THERMAL FLUX RATHER THAN A TRUE FAST FLUX, THE EXPERIMENT IS COMPLETE IN EVERY KEY ASPECT OF GCFR FUEL TECHNOLOGY.

PROGRAM SUPPORT

ELECTRIC UTILITY SUPPORT REPRESENTS 30% OF U.S. TOTAL

HELIUM BREEDER ASSOCIATES (HBA) IS A NON-PROFIT CORPORATION FORMED BY THE UTILITY COMPANIES IN 1976 AT THE REQUEST OF THE U.S. GOVERNMENT FOR THE SOLE PURPOSE OF SUPPORTING AND PROVIDING END-USER MANAGEMENT OF THE GCFR PROGRAM.

THE HBA COMPANIES REPRESENT A WIDE GEOGRAPHICAL CROSS SECTION OF UTILITY COMPANIES. THEY INCLUDE LARGE PRIVATE UTILITIES, RURAL COOPERATIVES, MUNICIPALS AND INDUSTRIAL MEMBERS.

UTILITY SUPPORT FOR GCFR GREW IN 1979 DESPITE THE PROBLEMS OF THE NUCLEAR INDUSTRY AND THE LOW PRIORITY GIVEN TO BREEDER DEVELOPMENT BY THE ADMINISTRATION.

CONTINUED INTERNATIONAL PARTICIPATION

EUROPEAN PARTICIPATION, STRONG UNTIL RECENTLY, IS IN A HOLDING PATTERN PENDING RESOLUTION OF THE U. S. POSITION ON BREEDER SUPPORT. TECHNICAL CONTRIBUTIONS CONTINUE TO FLOW FROM THE GERMAN NATIONAL LABORATORIES AT JUELICH AND KARLSRUHE, THE SWISS FEDERAL INSTITUTE FOR REACTOR RESEARCH AT WURENLINGEN AND EXPERIMENTS AT THE BELGIAN REACTOR CENTER AT MOL.

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HBA BOARD OF DIRECTORS

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Gas Company

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Robert S. Hunter
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c/o American Electric Power
Service Corporation

J. J. Scoville
Vice President &
General Manager

1979 HBA MEMBERSHIP & PROGRAM SUPPORT

Electric Cooperatives

- Bandera Electric Cooperative, Inc.
- Cherokee County Electric Cooperative Association
- Guadalupe Valley Electric Cooperative Association
- Medina Electric Cooperative, Inc.
- South Texas Electric Cooperative, Inc.
  - Jackson Electric Cooperative, Inc.
  - Karnes Electric Cooperative, Inc.
  - Nueces Electric Cooperative, Inc.
  - San Patricio Electric Cooperative, Inc.
  - Victoria County Electric Cooperative
  - Wharton County Electric Cooperative
- Surprise Valley Electrification Corporation
- Tri-County Electric Cooperative, Inc.

Public Utility Districts

- Public Utility District No. 1 of Clark County

Private Utilities

- Arizona Public Service Company
- Central and South West Corporation
  - Public Service Company of Oklahoma
  - Central Power & Light Company
  - Southwestern Electric Power Company
  - West Texas Utilities Company
- Cincinnati Gas & Electric Company
- Delmarva Power & Light Company
- East Central Nuclear Group (ECNG)
  - American Electric Power Company, Inc.
    - Appalachian Power Company
    - Indiana & Michigan Electric Company
    - Ohio Power Company
  - Allegheny Power System
    - Monongahela Power Company
    - Potomac Edison Company
    - West Penn Power Company
  - Ohio Edison Company
    - Pennsylvania Power Company
  - Columbus & Southern Ohio Electric Company
  - Southern Indiana Gas & Electric Company
  - Cleveland Electric Illuminating Company
  - Louisville Gas & Electric Company
- El Paso Electric Company
- Empire State Electric Energy Research Company (ESEERCO)
  - Central Hudson Gas & Electric
  - Consolidated Edison of New York, Inc.
  - Long Island Lighting Company
  - New York State Electric & Gas Corporation
  - Niagara Mohawk Power Corporation
  - Orange & Rockland Utilities, Inc.
  - Rochester Gas & Electric Corporation
- Northeast Utilities
  - The Connecticut Light & Power Company
  - The Hartford Electric Light Company
  - Western Massachusetts Electric Company
  - Holyoke Water Power Company
- Philadelphia Electric Company
- Public Service Company of Colorado
- Public Service Company of New Mexico
- Public Service Electric & Gas Company
- Puget Sound Power & Light Company
- Southwestern Public Service Company
- Union Electric Company
- Washington Water Power Company

International Utilities

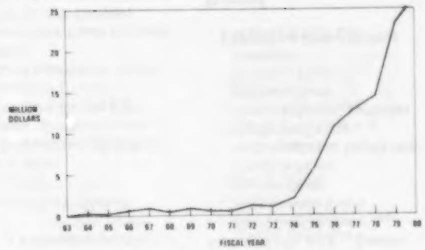
- ELSAM – Denmark
- AB Kaernkraft, AKK – Sweden
  - South Swedish Power
  - Skandinaviska Elverk
  - Voxnan Power
  - Krangede Power
  - Stora Kopparbeg Bergvik-Ala
  - Stockholm Energy
  - "Svarthalsforsen" Lanforsen
  - Balforsen Power
  - Gullspang Power
  - Uddeholm
  - Bergslagen United Utilities

Industrial

- Gilbert/Commonwealth
- Brown & Root

PROGRAM FINANCIAL SUPPORT

GOVERNMENT SUPPORT HAS GROWN WITH THE CONTINUED SUCCESS OF GCFR DEVELOPMENT



APPROXIMATE $200 MILLION IN DIRECT SUPPORT OF GCFR TECHNOLOGY

REVENUE SOURCES	CUMULATIVE THROUGH 1979 ($ IN MILLIONS)	1980 ($ IN MILLIONS)
UTILITIES/GENERAL ATOMIC	24	3
DOE	79	26
INTERNATIONAL	68	7
TOTAL	171	36

PROGRAM DESCRIPTION - FISCAL YEAR 1980

FY 80 IS THE THIRD YEAR OF PROJECT DEFINITION AND LICENSING PHASE (PDLP).

THE OBJECT OF THE PDLP IS TO PROVIDE:

- A HIGH CONFIDENCE COST ESTIMATE FOR A DEVELOPMENT PLANT BASED ON COMPLETION OF 70% OF THE ENGINEERING.
- ASSURANCE OF LICENSABILITY.
- COMPLETION OF R & D REQUIRED FOR BASIC ENGINEERING, eg.
  - COMPLETION AND OPERATION OF THE CORE FLOW TEST LOOP.
  - CONSTRUCTION AND OPERATION OF THE GCFR CIRCULATOR TEST FACILITY.
  - COMPLETION OF THE MAJOR PORTION OF THE FUEL IRRADIATION PROGRAM.

AT THE CONCLUSION OF THE PDLP, HBA, DOE AND OTHER INVOLVED PARTIES WOULD BE IN A POSITION TO MAKE A WELL-FOUNDED DECISION AS TO WHETHER TO PROCEED TO THE CONSTRUCTION PHASE OF A DEVELOPMENT PLANT.

FY 80 KEY RESULTS TO INCLUDE:

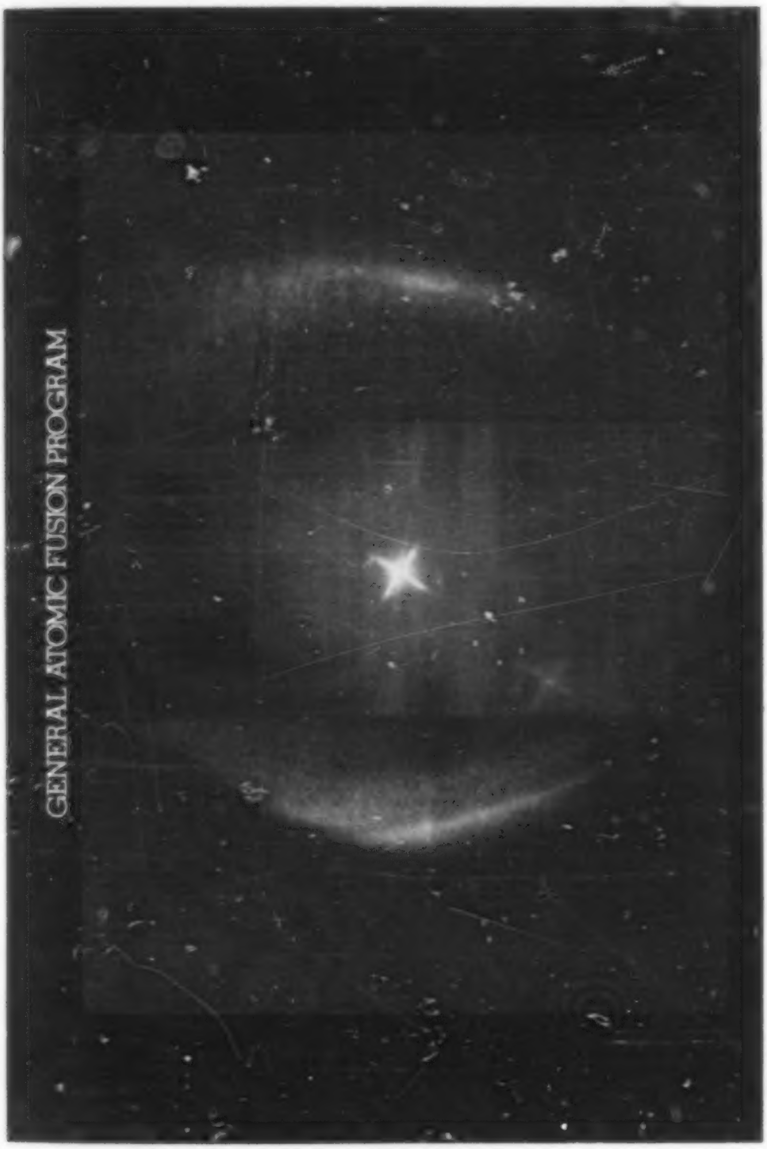
- COMPLETION OF CONCEPTUAL DESIGN OF GCFR DEVELOPMENT PLANT.
- COMPLETION OF DEVELOPMENT PLANS.
- COMPLETION OF FABRICATION OF COMPONENTS FOR FIRST TEST IN CORE FLOW TEST LOOP (OAK RIDGE).
- COMPLETION OF INITIAL SERIES IN ROD VIBRATION TEST RIG.
- COMPLETION OF MAIN CIRCULATOR BEARING TEST RIG.

RECOMMENDED PROGRAM - FISCAL YEAR 1981

CONTINUATION OF THE CURRENT PROJECT DEFINITION AND LICENSING PHASE (PDLP) SCHEDULE WOULD REQUIRE SUPPORT AT A LEVEL OF $42,000,000 FOR FY 81.

THE RECOMMENDED PROGRAM LEVEL FOR FY 81 IS $26,000,000. THIS REQUIRES A STRETCH-OUT OF THE PDLP BUT DOES PERMIT ACTIVITY TO CONTINUE ON ALL ASPECTS OF THE PROGRAM. SPECIFIC PROGRAM ACTIVITIES IN FY 81 WOULD INCLUDE:

- COMPLETION OF THE CORE FLOW TEST LOOP
- CONTINUATION OF THE IRRADIATION TEST PROGRAM FOR GCFR
- LIAISON WITH INTERNATIONAL GCFR EFFORTS
- MONITORING OF LMFBR AND THERMAL GAS PROGRAMS TO ASSURE CONTINUED INFLOW OF SHARED TECHNOLOGY
- CONCEPTUAL DESIGN OF BALANCE OF PLANT
- INITIATION OF PRELIMINARY DESIGN OF NUCLEAR STEAM SUPPLY SYSTEM
- RESOLUTION OF KEY LICENSING ISSUES


GENERAL ATOMIC FUSION PROGRAM

LIMITLESS ENERGY FOR THE FUTURE

Fusion duplicates the energy process of the sun.

Fusion is the energy source of the sun and stars. Harnessed here on earth, fusion power promises to be not only an inexhaustible source of energy for future generations, but also one that is safe and has minimal impact on our environment. The General Atomic Fusion Group represents the largest effort within private industry dedicated to fusion research, development, design and construction. Building on the Company's broad experience in advanced technology systems development, and on its 20 years in fusion research, GA has constructed Doublet III, one of the world's most advanced fusion devices. This effort enjoys the financial support of the U.S. Department of Energy and the Electric Power Research Institute. The Fusion Group is also working on commercial fusion development contracts awarded by other private industries and national laboratories and participates in several international cooperative agreements. The latest of these is a multiyear agreement with the Japanese government to do cooperative research in fusion.

Fusion is the joining, or fusing, of two light atoms — unlike fission, which is the splitting of a heavy atom. When fusion occurs, mass is converted to energy. It is this energy, in the form of heat or charged particles, that can be used in fusion reactors to generate electricity or to provide power for process heat applications.

The basic fuel for fusion is deuterium, an isotope of hydrogen that is present in ordinary water. Each gallon of water contains enough deuterium to produce fusion energy equivalent to 300 gallons of gasoline. Extracting the deuterium from water costs only pennies per gallon and has no harmful environmental effects. The deuterium present in the oceans is sufficient to supply the world's energy needs for a billion years at present rates of consumption, and thus it constitutes a virtually limitless source of fuel.

The promise of inexhaustible power would be an empty one if there were safety problems or adverse environmental side effects. But fusion also looks attractive in these respects. The total amount of fusion fuel present in a fusion reactor at any one time is small, and the physics of the fusion process makes a runaway reaction impossible, even if part of the reactor system fails. There is no significant overheating problem if the reactor coolant is accidentally lost.

Although radioactivity is generated in the reactor structure in the fusion process, the amounts and biological hazards are manageable.

Fusion reactors will not release chemical combustion products to the atmosphere, since there are none in fusion. The amount of heat released to the environment will be no greater than that from present day fossil-fuel burning power plants. Advanced fusion fuel cycles promise eventually to yield direct conversion of fusion energy to electric power, with higher efficiency and less waste heat. Fusion reactor siting is not dependent on geography, climate or weather, and thus will allow great flexibility in plant location.

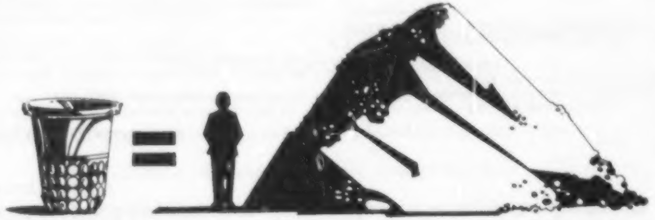
The role of fusion is not limited to electric power generation. Other roles are in commercial process heating and in chemical applications such as hydrogen production.

Fusion may also be used in conjunction with fission power systems to breed alternative fission fuels or to "burn," or convert radioactive wastes from fission plants to more benign materials. A symbiotic combination of fusion and fission reactors has the potential to enhance both technologies and may represent an effective solution to the nation's midterm energy needs.

To Imitate the Sun

Fusion occurs only at extreme temperatures. The process for achieving fusion by magnetic confinement uses magnetic fields to "bottle up" a gas of charged particles, called a plasma, which can then be heated to more than 100 million degrees Celsius. The high temperature causes the charged particles to overcome their natural repulsion. They fuse, releasing energy. In another process, called inertial confinement, a number of intense beams (either laser-produced light beams or electron beams) are simultaneously focused for less than a billionth of a second on tiny pellets containing the fuel material. The result is a rapid implosion of the pellet, simultaneously creating a plasma from the pellet and raising its temperature to the fusion reaction level.

The challenge of fusion research and development is to produce a continuous, controlled fusion reaction on a scale large enough to provide economical power in commercial quantities.



A thimbleful of pure deuterium has the energy equivalent of 20 tons of coal.

One out of every 6,500 hydrogen molecules in sea water is deuterium. Thus, sea water can provide us with an abundant energy source.

THE FUSION PROGRAM

The plasma in the Doublet III device is so hot that it gives off visible light only at the edges.

Controlled thermonuclear fusion research has been under way at General Atomic since 1957. The major emphasis has been on the development of innovative approaches to magnetic confinement, but fusion research programs are leading to new energy developments of many kinds.

Unique Capabilities

The fusion program at General Atomic has led to the creation of a broad range of capabilities:

- Extensive experience in building fusion devices, especially such large systems as Doublet III, the state-of-the-art experiment in fusion.
- Experience in fusion reactor design. GA has completed a Fusion Experimental Power Reactor Design Program for the Electric Power Research Institute and is participating in the Engineering Test Facility Design Center, exploring designs for the next fusion device in the Department of Energy's national fusion development program. GA is also a participant in a design study together with Argonne National Laboratory for the development of a comprehensive design of a commercial tokamak[*] fusion reactor and its associated power plant.
- An in-depth program for fusion systems and technology encompassing the challenges of engineering the environment within the reactor, fueling, heating, containment and safety; power conversion systems; fusion reactor applications; hybrid (fusion-fission) reactor designs; and alternative fusion concepts. These engineering efforts are also being extended toward other energy sources, including solar energy.
- An experiment to study optimum plasma conditions, conducted in conjunction with Oak Ridge National Laboratory in the Impurity Study Experiment (ISX) device.
- A theoretical plasma physics program that utilizes the National Magnetic Fusion Energy Computer Network.
- Participation in international cooperative fusion programs on INTOR (an international tokamak), TEXTOR (Federal Republic of Germany) and Doublet III (together with scientists from Japan).
- Commercial capability to design and construct fusion technology components for industry. For example, GA is working with Los Alamos Scientific Laboratory on the first commercial application of superconducting magnet technology for the utility industry, using a superconducting coil for energy storage.
- Cooperative programs with other private industries in fusion device development.

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[*] Tokamak is a Russian word signifying a toroidal (doughnut-shaped) magnetic confinement chamber.

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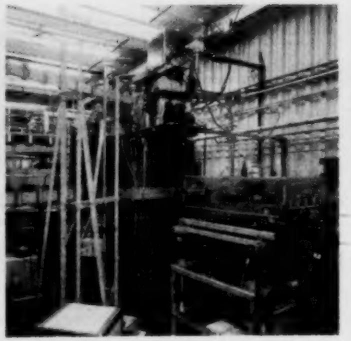
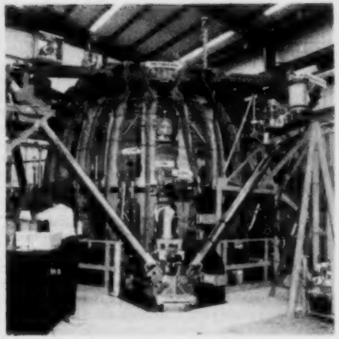
The Company's Doublet I fusion device proved that a stable plasma could be maintained for adequate time periods (1968-1969).



Results obtained from Doublet IIA have shown that a "doublet" plasma shape provides significant improvements over circular plasma shapes in plasma density and energy confinement time. Doublet IIA also provided critical information for the design of Doublet III and studied the possibility of using radiofrequency (rf) waves as a method of heating tokamak fusion reactors (1975-1979).



Doublet III is General Atomic's current major fusion project (1978 to the mid 1980s).

The Doublet Concept . . .
A Significant Discovery

From the beginning, the fusion research program at General Atomic has been aimed at developing the most economical fusion reactor possible. This basic point of view led directly to the Doublet concept, based on the General Atomic discovery that a "doublet" or kidney-shaped plasma cross-section can yield significant benefits in reduced size and cost of a fusion reactor.

The Doublet experimental research program began with small devices that performed experiments that helped to determine the necessary physical size of a machine to demonstrate the conditions required for a self-sustaining fusion reaction. Accordingly, GA built a succession of ever more sophisticated machines: the multipole, dc Octopole, Doublet I, and Doublet II and IIA to test confinement theory and noncircular cross-section plasmas. Now Doublet III will demonstrate reactor-like conditions.

Program Accomplishments

1961	Toroidal quadrupole produces first stable plasma pinch.
1965	Toroidal octopole shows longer confinement than "Bohm time."
1969	dc Octopole produces first "perfect" magnetic bottle.
1969	Doublet I produces first noncircular plasma.
1974	Doublet IIA begins operation.
1977	Doublet IIA shows potential advantages of doublet shape for plasma stability, power and magnet efficiency, lower reactor costs.
1979	Doublet III obtains largest plasma current yet achieved in a tokamak device.

FUSION TODAY AND TOMORROW

Fusion is expected to play an ever-increasing role as an inexhaustible energy resource for our nation. As the many technological and engineering challenges of developing fusion power are met, it will likely become one of the world's most desirable energy sources. Commercial fusion reactors are projected to be under construction by the year 2010.

Fusion energy will generate electricity or provide power for process heat applications.

Doublet III

The Doublet III program is a key element in the national fusion development effort of the U.S. Department of Energy. The Doublet III tokamak incorporates the knowledge gained from the previous Doublet experiments into a large machine that is the first fusion device capable of approximating the physics parameters necessary for commercial fusion power reactors. The ultimate goal of the experiment is to obtain thermal "breakeven"* conditions in a hydrogen plasma, while at the same time demonstrating the potential economic advantages of the doublet noncircular cross-section.

Operation of Doublet III will be divided into two phases, an ohmic heating phase and a neutral beam heating phase. The ohmic heating phase, expected to last until early 1980, will heat the plasma resistively to 10-20 million degrees Celsius. At the end of this phase, reactor-like plasma parameters of density (n) times energy confinement time (τ) of 10^{14} cm^{-3} sec are anticipated. Because ohmic heating is effective only up to 20 million degrees, additional heating must be provided. A hydrogen beam injection system, which uses highly accelerated hydrogen atoms to impart energy to the plasma, will be installed in 1980. During the operation of the initial 7.2 MW of beam power, studies will be conducted on plasma confinement, increasing the plasma temperature, and determining the optimum plasma shape for future reactor designs.

International Cooperation

An upgrade of Doublet III is part of an international cooperative agreement in energy research between the governments of the United States and Japan. The upgrade will allow operation of Doublet III at its full engineering design capability and includes a total of 22 MW of neutral beam heating. Japanese scientists are participating in the experimental program at the General Atomic site.

The upgrade capabilities will allow the attainment in a hydrogen plasma of the breakeven condition — the simultaneous demonstration of a high-temperature (70 million degrees Celsius) reactor-grade plasma with both high density and long confinement time ($n\tau = 10^{14}$ cm^{-3} sec). The realization of the breakeven condition will be the first major step in the demonstration of fusion energy's engineering, economic and environmental feasibility.

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*The point where the energy released in a fusion device equals energy invested in heating and containing the plasma. The values of the plasma parameters when this occurs are described as the breakeven condition.

After Doublet III

As part of the Department of Energy's long-range plan for commercialization of fusion power, a number of fusion devices will be constructed to test engineering components and systems. As a response to this plan, General Atomic has investigated various designs for the next stage of development after Doublet III. This effort was accomplished under the auspices of the DOE's "The Next Step" program, which will result ultimately in a reactor concept that will be chosen to become magnetic confinement's Engineering Test Facility.

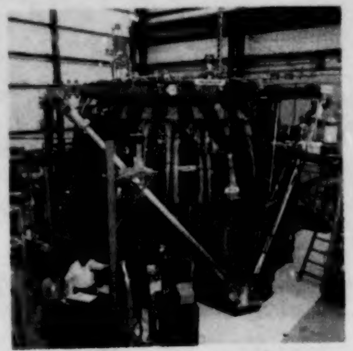
In the design studies, GA scientists and engineers investigated the desirable physics, engineering and programmatic characteristics of a power-producing tokamak. The chosen design was to allow the device to be scaled up eventually to become an attractive energy producer. The design that emerged from these studies, termed the Power Generating Fusion Reactor or PGFR, represents the minimum-cost device that produces a reactor-grade plasma, incorporates reactor prototypical components and systems, and demonstrates the production of electric power from fusion reactions. An important element in the lower cost of the design is the use of a doublet-shaped plasma; this permits a smaller reactor size without sacrificing power production. A device with these characteristics will provide the design basis for proceeding with a Demonstration Power Plant.

Diversity of Support

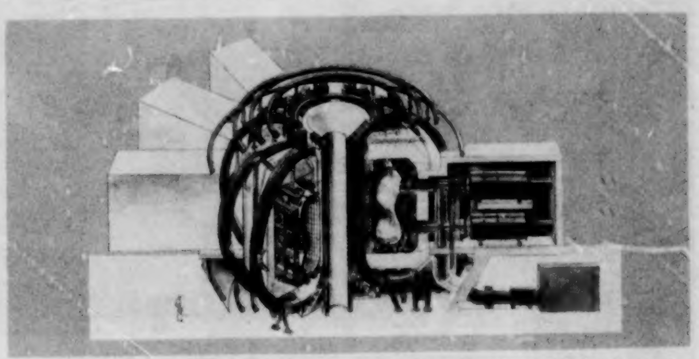
The fusion program at General Atomic enjoys the support of both industry and government. Conceptual design and engineering studies for Doublet III were sponsored by the Edison Electric Institute and the Electric Power Research Institute, and construction of the basic device was funded by the U.S. Department of Energy. Costs of upgrading capabilities of the device and of operation are to be shared by the governments of the United States and Japan. The applied plasma physics and development and technology programs receive continuing support from the DOE.

Through other projects sponsored by the Electric Power Research Institute and individual utilities, the electric utility industry has contributed funds to support the design and implementation of fusion reactor concepts and technology.

The multifaceted fusion research and development program being conducted at General Atomic should help ensure continued significant contributions in the national fusion program.



Doublet III will be able to approximate the physics conditions required for operation of a fusion reactor. The device is shown with various diagnostic tools installed that are used to measure conditions during an experiment.



The PGFR is a design proposed by GA as a follow-on to Doublet III. Its purpose is to test the systems and components that are prerequisites to the design of a commercial reactor.

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GENERAL ATOMIC

General Atomic Company
P.O. Box 81608, San Diego, California 92138

Senator **Matsunaga**. We will now hear from Dr. Boyer.

STATEMENT OF DR. VINCENT BOYER, SENIOR VICE PRESIDENT, PHILADELPHIA ELECTRIC CO., PHILADELPHIA, PA.

Dr. **Boyer**. Mr. Chairman, my name is Vince Boyer, and I am senior vice president of Philadelphia Electric Co. Today I am appearing on behalf of Gas-Cooled Reactor Associates (GCRA), a utility/user orgnization which is playing a key leadership role in this Nation's high temperature gas-cooled reactor (HTGR) program. At the present time, 29 utilities representing approximately 25 percent of the U.S. generating capacity are involved in GCRA.

This company was formed and is supported directly by the utility industry. The utilities have had an interest in the gas-cooled program for over 20 years and I have been associated with it for that long, since I served as the first superintendent of our Peach Bottom gas-cooled reactor plant.

Today we have 25 percent of the capacity of the utility industry supporting the gas-cooled reactor program in GCRA. The utilities are participating in the design and development of the projected plants for the future.

We have a soundly based program which is not only based on the 7-year operation of our Peach Bottom No. 1 prototype gas-cooled reactor, but also on the current operation of the Fort St. Vrain plant, today running at something in the neighborhood of 50 percent power.

You might ask, are we, the utilities, interested in the gas-cooled program. Basically, today it is because of the unique high temperature applications which it offers through the utilization of gas turbines for the direct production of electricity and for the supplemental production of processed heat and its applications.

In the processed heat area, we include not only steam for byproduct use in industrial areas, but also the production of what we call portable energy. This could be synthetic gas in the form of hydrogen carbon monoxide or in the form of hydrogen, or a combination of these gases.

The gas turbine cycle is a closed cycle, a simple system having a high efficiency. It discharges its heat at a relatively high tenperature compared to current fossil fuel plants so that dry cooling can be utilized and, thus, the gas-cooled system can free utilities from the need of larger water requirements for cooling the exhaust steam.

The HTGR system is the only one having the capability of displacing fossil fuels today and freeing us from the siting restrictions related to water requirements.

A second interest of utilities in the gas-cooled program is due to the siting advantages. I have mentioned the freedom from water, but there are other advantages in basic design of the gas-cooled reactor. These relate to the large core heat capacity which the ceramic fuel produces, creating inherent safety advantages.

It also uses a single phase coolant, namely, helium, and it uses a prestressed concrete reactor vessel of massive strength.

These are inherent protection advantages to the facility and to the health and safety of the public. A third reason that we are interested is because of the flexibility in the utilization of fuel in the high-temperature gas-cooled reactor system.

The fuel design can accomodate any national policy direction. The fuel has a high thermal efficiency. The reactor can be designed with a high conversion ratio and the fuel has excellent utilization.

The plant operation is associated with very low radiation in the equipment areas and so maintenance and operation of the plant can be done almost as routinely as it is currently done with conventional plants.

The plant has low environmental impact because of the low radiation level, the inert condition of the fuel and the inert condition of the helium. Thus, because of these advantages we were sorry to see that the administration had terminated the programs in the proposed budget and we request restoration of support in the project so that we can establish an initiative for a lead project. We were pleased to see that the House Committee on Energy Research and Production has recommended $50 million for the HTGR program, which includes support for the spent fuel area. GCRA has underway a comprehensive program to identify a lead program for the high temperature gas-cooled reactor by the end of fiscal year 1980.

An evaluation document has been prepared in cooperation with General Atomic, General Electric, and the Oak Ridge National Laboratory to set forth the basis for the lead plant program definition.

The program needs to be site and owner specific and must consider licensing and technical issues as well as the economics. To accomplish this, we must establish the cost hearing basis between utilities, the suppliers, and the Government.

The lead project is vital to the establishment of a national high-temperature gas-cooled reactor program, which we expected to do in the 1980's, and in 1981 we feel that the program should proceed on the lead plant conceptual design. We are, therefore, requesting a $55 million funding level and plan to be prepared to yield a cost effective program with this support.

The House committee has recommended $46.5 million, but our minimum budget request to complete the work which we feel is essential, amounts to $55 million.

There is additional language also included in our proposal, and that is to consider the spent-fuel treatment. We request $5 million for this program. The House has recommended $3.5 million. We have a cooperative program in this area, in the spent fuel area, with the Federal Republic of Germany, which we feel is a valuable program and will produce optimum results for both our country and Germany.

We, thus, feel that it is an essential part of the overall program and recommend support for it.

In summary, then, the utilities believe that the HTGR offers advantages to the utility industry and to the Nation as a whole. We feel the high-temperature characteristics provide unique nuclear applications that address the national energy problems of power-plant siting and of portable fuel supply.

Accordingly, we urge the Senate Subcommittee on Energy Research and Development to support an aggressive HTGR program.

Thank you.

Senator MATSUNAZA. Thank you very much, Dr. Boyer.

[The prepared statement of Dr. Boyer follows:]

STATEMENT SUBMITTED FOR THE RECORD

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

FY'81 DOE BUDGET FOR THE HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

VINCENT S. BOYER

SENIOR VICE PRESIDENT OF PHILADELPHIA ELECTRIC COMPANY

SUBMITTED TESTIMONY ON BEHALF OF

GAS-COOLED REACTOR ASSOCIATES

APRIL 1, 1980

Mr. Chairman, my name is Vince Boyer, and I am Senior Vice President of Philadelphia Electric Company. Today I am appearing on behalf of Gas-Cooled Reactor Associates (GCRA), a utility/user organization which is playing a key leadership role in this nation's High Temperature Gas-Cooled Reactor (HTGR) Program.

The utilities' interest in the HTGR spans a period of more than 20 years. This interest has led to major design and development contributions from the utility industry to the HTGR Program. These contributions include activities that have led to the Peach Bottom prototype plant, which was operated successfully for seven years by the Philadelphia Electric Company, and the Fort St. Vrain demonstration plant, which is in service on the Public Service Company of Colorado's system.

Since 1978, Fort St. Vrain has generated over 1.2 billion KWhs. With a design rating of 330 MWe, the plant has successfully operated up to 70% power, with higher level operations restricted by the Nuclear Regulatory Commission until further testing and review are completed. While Fort St. Vrain has experienced some difficulties in its rise to power, it has provided critical confirmation and demonstration of many key HTGR concepts. Significant is the HTGR's excellent fuel performance and the resulting low radiation exposure to plant personnel documented during the refueling outage in 1979. There has been excellent correlation between predicted fuel performance and observed data. Radiation dose rates on primary system components have been and continue to be low enough to warrant substantial direct contact maintenance. Other major contributions of Fort St. Vrain have been in the areas of core physics confirmation, plant control and response, and plant performance at high temperatures. Plant operating experience to date has demonstrated predictable, easily managed performance even during extreme modes of operation including temporary loss of forced cooling. The high core heat capacity has shown temperature transients to be slow, predictable, and easily controlled. Fort St. Vrain has also demonstrated high performance and high temperature capabilities. Operation to date has achieved 1400°F primary loop and 1000°F steam temperatures--the highest of any nuclear plant in the U.S.

GCRA was formed about two years ago through the combined efforts of a concerned group of utility and industry executives and government officials who believe that the United States should have the HTGR as a commercially available option. The role of GCRA is responsive to the institutional need for front-end participation in technology development by the end-user of the technology. This role ensures that the investment of government and private sector resources will result in HTGR systems that will most favorably impact the U.S. energy economy. A full-time professional staff, supported solely by utility financial contributions, is in place to fulfill the GCRA programmatic role. Direct utility input and guidance is provided through the GCRA Board, a Management Committee, and a Technical Advisory Committee.

In spite of the tumultuous climate within the nuclear power industry, 1979 has been a year of significant institutional progress for the HTGR Program. The following examples are noted:

1. The utility/user support of and participation in GCRA have increased significantly. At the present time, 29 utilities representing approximately 25% of the U.S. generating capacity are involved in GCRA.

2. The formation of the HTGR Process Heat Users Group which serves to focus the interest of the process user industry in the development of the HTGR and to provide technical and programmatic guidance to the organizations participating in the development of Process Heat applications.

3. The added corporate support of the General Electric Company which is a key step toward broadening the industrial supply base in the HTGR Program.

4. The DOE's initialing of the "Implementing Agreement" with the Federal Republic of Germany and Switzerland. This agreement defines the intent and structure for international cooperation in HTGR development.

The primary bases for this progress are associated with the unique attributes of HTGR technology which are responsive to current national energy problems of power plant siting and portable fuel supply. These attributes are manifested in two application categories--Closed Cycle Gas Turbine and Process Heat.

In the former application, the reactor heat energizes a closed cycle gas turbine to generate electricity. In addition to the basic simplicity and high efficiency offered by this concept, the gas turbine is characterized by a high heat reject temperature, typically 300°F or higher. This latter characteristic leads to economic application of dry cooling in contrast to steam cycle systems which are dependent upon low heat reject temperatures, typically less than 100°F to maintain efficiency. As water becomes increasingly scarce in many areas of the country, priorities for municipal systems, agriculture, and industry will increasingly limit water available for power generation. Thus, water conservation through dry cooling provides a major incentive for the HTGR-Gas Turbine. Alternatively, the high temperature reject heat may be used for various bottoming power cycles and/or cogeneration applications to further increase the overall efficiency of the system. At the present time, the primary design effort is directed at the Gas Turbine.

In the various Process Heat applications, part of the reactor heat is used to produce a portable energy source in conjunction with electricity generation. This energy source can be in the form of process steam, synthesis gas (which is a mixture of hydrogen and carbon monoxide), hydrogen, or a combination of these forms. In process steam and cogeneration applications, the HTGR provides high temperature, high pressure process steam which is currently available only through fossil resources. In advanced applications, the HTGR produces synthesis gas, which has applications for peaking generation, synfuels production, direct iron ore reduction in steelmaking and transportation of energy to remote industrial users through the thermochemical heat pipe concept. In more advanced applications, the HTGR can be used as the heat source for the direct production of hydrogen, through the thermochemical splitting of water. Of all reactor systems, either current or under development, the HTGR alone holds the promise for major displacement of fossil fuels (notably oil and gas) through Process Heat applications.

Further, the different safety characteristics of the HTGR may allow for improved siting flexibility, opening sites otherwise unavailable for nuclear power facilities. The large heat capacity of the HTGR core, the high-temperature characteristics of the ceramic fuel components, the single-phase helium coolant and the massive prestressed concrete vessel all lend characteristics to the HTGR that make it inherently safe and very forgiving with regard to transients and operational upsets. These characteristics provide inherent protection to the facility as well as inherent protection to the public health and safety.

In addition, the HTGR provides important advantages associated with (1) unique flexibility for adopting fuel design changes due to national policy changes or technology advances, (2) low fuel consumption associated with the high conversion ratio and high thermal efficiencies, and (3) low occupational radiation exposure and environmental impact associated with the high retention fuel design and inert helium coolant.

Recognizing the incentives of the HTGR technology and the institutional progress gained over the past year, it is particularly frustrating that the Administration submitted a budget that terminates the HTGR Program in FY 1981. In spite of that frustration, we are here today to submit our recommendations for not only restoring the HTGR Program but establishing an initiative toward a Lead Project. It is noted that to date, significant progress has been achieved within Congress for restoring the HTGR Program. The House Subcommittee on Energy Research and Production has voted to support a budget level of $50.0 million for the HTGR Program, including spent fuel treatment activities.

While incentives for HTGR development have been consistently identified in recent studies, a number of barriers prevent unassisted deployment of HTGR technology on a warranted commercial basis. Although technical issues remain to be resolved, institutional barriers comprise a more difficult challenge. Included in these institutional issues are the following:

- Commercial deployment of a new reactor technology involves a significant investment on the part of both the government and the industry.
- National energy policy, particularly with regard to nuclear energy, has been inconsistent, unstable, and to a large extent hostile.
- The regulatory environment pertaining to energy in general and to nuclear energy in particular has become increasingly onerous during the past decade.
- The flexibility provided electric utilities to assume major development risks has been increasingly diminished by the inability to obtain adequate rate relief from commissions having jurisdiction over utility rates.
- The licensing basis for gas-cooled reactors is yet to be developed in the context of current requirements. The most recent exposure of the HTGR to the detailed scrutiny of the licensing process now dates to the mid-1970's.

In view of the above, the risk relative to deployment of any HTGR application could only be evaluated as open-ended and unacceptable by any prudent business analyses at the present time. The conclusion is that the only feasible path to HTGR deployment on a commercial basis is demonstration through a federally assisted Lead Project. Further, the Lead Project must fulfill some very specific requirements in order to overcome the institutional barriers described above:

- The Lead Project must be subjected to the full scrutiny of the licensing process.
- The Lead Project must provide a basis for developing normal user/supplier business relationships.
- The Lead Project must provide a basis for utility experience in plant ownership/operation.

While the significance of a Lead Project is paramount, the exact configuration to be demonstrated is of lesser importance in addressing institutional issues. In support of this point, it should be recognized that fundamental design and fabrication technologies are essentially the same for components and structures comprising more than eighty percent of the nuclear island facility in any of the HTGR concepts being considered. Included are the prestressed concrete reactor vessel, the graphite core and internal structures, fuel handling provisions, core auxiliary cooling systems, and major balance-of-plant structures and systems such as the containment, and reactor service facilities. Accordingly, any of the Lead Project options under consideration provides an adequate basis for establishing HTGR licensing requirements and for testing the HTGR in the present institutional environment.

GCRA has initiated a comprehensive effort to identify an HTGR Lead Project by the end of FY 1980 that will be supported by all Program participants. A detailed Program Plan, prepared in cooperation with General Atomic, General Electric, and Oak Ridge National Laboratory, has been prepared that describes the evaluation and selection process. Major elements of the Plan include investigation of specific candidate Lead Project options through specific site-related application studies, and a formal evaluation process involving all major Program participants. Key factors in selecting the Lead Project will include the level of participation by potential utility owners/operators, compatibility with long-term objectives, technical and licensing issues and projected economics. The approach to the Lead Project is based on the establishment of an equitable basis for sharing the costs and risks among the government, the utility/user industry, and the supplier industry. Critical in this regard is to assure an incentive-based arrangement whereby each party has a vested interest in assuring success.

Following Lead Project selection in 1980, the reference schedule calls for conceptual design of the Lead Project to be completed during FY 1981 and 1982. To meet program goals, authorization for the preliminary design phase of the Project must be provided for in the FY 1983 budget. Construction start is projected for 1988, with full power operation targeted for 1994. The reference project schedule may be adjusted depending upon the Lead Project option and the desired funding strategy.

The Lead Project options are (1) the Gas Turbine application, (2) a Reforming application, (3) a Process Steam/Cogeneration application, and (4) a Nuclear Heat Source Demonstration Reactor which supports the development of both Gas Turbine and Reforming technology. The first two Lead Project options represent direct paths to commercial Gas Turbine and Process Heat applications, respectively. The Gas Turbine option will demonstrate base load electricity generation on a water-restricted site. The Reforming option will demonstrate the application of synthesis gas for repowering existing generation facilities currently using oil or natural gas or for base load plus peaking generation. The remaining two Lead Project options represent indirect paths to long-term program objectives. In the case of the Process Steam/Cogeneration plant, near-term technology is utilized to supply base load electricity plus the potential application to displace oil and/or natural gas through the delivery of process steam. The resulting industrial base provides a foundation for further development of the Gas Turbine and Reforming applications. The fourth option, the Nuclear Heat Source Demonstration Reactor, represents a more flexible developmental approach. In this concept, heat from the reactor will be transferred to a secondary loop via an intermediate heat exchanger. Secondary loops will successively demonstrate a Gas Turbine power train and a Reforming power train.

In summary, the identification of a Lead HTGR Project that is supported by all Program participants is vital to the establishment of a National HTGR Program. The FY 1980 Program provides a basis for that achievement. Accordingly, GCRA requests that Congress take the following action.

First and foremost, it is critical that the Program be directed in support of a focused Lead Project as opposed to another year of base technology development and market studies. This aspect is considered crucial for strong utility/user support and participation as well as stable government support. Accordingly, it is recommended that Congress direct the FY 1981 effort to proceed on a Lead Plant conceptual design and project plan needed to support Title I authorization for a Lead Project. With regard to the FY 1981 budget requirements, a funding level of $55 million is requested to support the initiative on a Lead Project. This estimate has been developed by Program participants over the past several months. Detailed work plans and resources are prepared to pursue this course and produce cost-effective results. It is noted that the House Subcommittee on Energy Research and Production has voted to support a budget level of $46.5 million for the HTGR Program. While this is viewed as positive support, we urge this Subcommittee to consider increasing the HTGR budget level to the recommended $55 million level.

An additional element to be considered in the HTGR Program is the Spent Fuel Treatment Program, which includes all spent fuel management activities. Funding for such work, which was included in the Consolidated Fuel Cycle Program, has also been zeroed in the Administration's budget. Recognizing the necessity to close any reactor system's fuel cycle, it is important that the HTGR Spent Fuel Treatment Program be continued. It is recommended that a Program be maintained at a funding level of $5.0M. It is noteworthy that one of the most cost-effective cooperative programs under way with the Federal Republic of Germany is in the area of spent fuel treatment. The recommended budget level is commensurate with maintaining such cooperation. Effective international cooperation in this area is most important since the total cost for closing a nuclear fuel cycle is high and there is a desire to promote uniform proliferation resistant fuel cycles on an international basis. For this budget item, the House Subcommittee has voted to support a level of $3.5 million, which again is viewed as positive support to the HTGR Program.

In summary, the following recommendations are made with regard to the FY 1981 budget for the HTGR Program:

1. Establish a Lead Project-oriented Program that adds near-term focus for the Program participants and contributes toward the long-term objectives.

2. Establish a budget level of $55M for the HTGR Program.

3. Establish an HTGR Spent Fuel Treatment Program at a budget level of $5.0M.

The utilities of Gas-Cooled Reactor Associates believe that the HTGR offers significant advantages to the utility industry and the Nation as a whole. The high-temperature characteristics of the HTGR provide unique nuclear applications that address the national energy problems of power plant siting and portable fuel supply. Accordingly, we urge that the Senate Subcommittee on Energy Research and Development support an aggressive HTGR Program.

Mr. Chairman, that concludes my prepared statement. Thank you for the opportunity to present the utility viewpoint to your Subcommittee.

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Senator **Matsunaga**. We will now hear from Mr Davis.

STATEMENT OF RALPH M. DAVIS, PAST CHAIRMAN, PUGET SOUND POWER & LIGHT CO., BELLEVUE, WASH.

Mr. **Davis**. Thank you, Mr. Chairman. In the interest of time, I would request that my more complete statement be incorporated into the record.

Senator **Matsunaga**. Without objection, it is so ordered.

Mr. **Davis**. I will briefly summarize that statement. Some of the points have been made by Dr. Agnew.

I am appearing here in my capacity as chairman of Helium Breeder Associates, the nonprofit corporation that is made up of the 77 companies who are the corporate financial supporters of the gas-cooled fast-reactor technology.

This program has not been included in the administration's proposed fiscal year 1981 budget. I am appearing here to urge your committee to reinstate it.

Our group also supports a strong liquid metal breeder development program, and we are convinced that the ultimate need for breeder reactors in this country will be of such importance that we ought not to have all our eggs in one basket and that we should continue to develop alternate technology.

The GCFR program is an alternative which draws on both LMFBR and HTGR technology, and because it is incremental in nature, it is very cost effective. It offers some very attractive possibilities by comparison to other breeder concepts, such as higher breeding performance, lower capital cost, and advantages in operability and maintainability.

These possible advantages cannot be properly assessed until further design and development work is completed.

The project is currently aimed at further developing the base technology, completion of about 70 percent of the engineering design, completion of licensability studies, and development of a cost estimate for a small-sized reactor. Several design verification and testing programs are underway or planned.

Among them are a core flow test facility at Oak Ridge National Laboratory where $16 million has already been spent, and a proposed circulator test facility—a $31 million program to modify an existing but unused facility at the Idaho National Engineering Laboratory.

The segment of the utility industry supporting the GCFR constitutes about 30 percent of the electric generating capacity in the United States. The program has evolved over many years as a joint industry/Government effort. Recent assurances provided by the administration and the Department of Energy led us to believe that the alternative breeder technology development program was still a part of the overall administration's nuclear policy, and we were unaware of any policy change until we learned of the deletion of this program from the fiscal year 1981 budget request.

After President Carter's energy policy statement in April 1977, HBA made efforts to determine whether the Government would continue to support the GCFR and received an affirmative response from the Government in a letter to HBA management.

After responding to a Government request for a GCFR program manager, HBA entered into a contract with DOE in 1979 signifying a mutual commitment to the program. President Carter endorsed the continuation of it in a letter to Speaker of the House 0'Neill, and the Government published two other reports endorsing the management concept and the GCFR program.

I have been encouraged by these Government assurances. Our organization has been able to increase participation in its membership in the past year. Seven new utility companies and two new industrial members have been added in just this past year.

So we think the abrupt withdrawal of a Federal partner which has taken us by surprise, has one unfortunate aspect, leaving the industry with an uneasy feeling of the reliability of further industry-Government cooperation in these long-term projects.

General Atomic is the prime contractor on the nuclear steam supply system, although other nuclear vendors also perform some of the work under contract to HBA. Engineering work is being carried out by such firms as Bechtel, Stone & Webster, Gilbert Commonwealth, Brown & Root, Parsons and others.

Research and development is being done at national laboratories such as Argonne, Oak Ridge, Pacific Northwest, Idaho National Engineering Laboratory, Los Alamos, and Brookhaven. We have member utilities from foreign countries, and through cooperative arrangements some work is being perfromed in Switzerland, Germany, and Belgium.

We believe that if the United States took a more aggressive posture with respect to the GCFR, even more significant cooperative arrangements could be made with foreign countries in support of an overall breeder program.

Not just a GCRF, but an overall program.

Many countries participating with the United States on the GCFR Coordinating Committee of the Organization for Economic Cooperation and Development, look to this country for leadership in GCFR development.

If this joint industry-Government partnership effort is dissolved unilaterally, it will be yet another example of the Government's inability to work cooperatively with industry.

In addition, it is likely that we will never regain the position of leadership that we now enjoy worldwide with respect to gas-cooled fast-reactor technology.

I refer you to my more comprehensive statement for further discussion of the concept, but I urge your support of our request for reinstatement of funding for this program.

Our program plan would have called for funding at a level in excess of $40 million for fiscal year 1981. However, the program can be pursued and advanced, and our utility membership and industrial financial participation maintained if funding is restored at least at the $26 million level of the current year.

Thank you very much for the opportunity to present this testimony. I request that my complete statement be included in the record along with the attachments.

[The prepared statement of Mr. Davis follows:]

STATEMENT BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

U. S. SENATE

FY'81 DEPARTMENT OF ENERGY AUTHORIZATION

Gas-Cooled Fast Reactor (GCFR)

April 1, 1980

Ralph M. Davis, Chairman
HELIUM BREEDER ASSOCIATES

Mr. Chairman, Members of the Committee:

Thank you for the opportunity to present testimony to your committee today. I am Ralph M. Davis, Chairman of the Board of Helium Breeder Associates (HBA), and I am speaking to you today on behalf of the 77 utilities and industrial participants who are members of the HBA company, and financial supporters of the development of the gas-cooled fast breeder reactor technology. The Gas-Cooled Fast Reactor (GCFR) program has not been included in the Administration's proposed 1981 budget, and I am here to urge you to reinstate it and provide funds for its continuence.

Helium Breeder Associates also supports a strong and vigorous LMFBR development program at a much higher funding level than that provided in the Administration's proposed budget. We believe that a strong and diversified breeder program is imperative if this country is to meet its energy needs in the future. As an indication of the broad and vigorous support from the GCFR, the HBA members, the European supported GCFP programs, and GA have provided funding support of $92M in parallel with the U.S. government support of $79M through 1979.

The GCFR program has for many years been considered an alternative development effort which is incremental in nature to the LMFBR mainline program. The GCFR program draws both on the technology being developed by the participants of the LMFBR program and on that technology now being demonstrated in the Fort St. Vrain gas cooled reactor. The program is designed to be incremental and therefore cost effective.

The GCFR is currently in the Program Definition and Licensing Phase or PDLP, which has as its end goals the completion of approximately 70 percent of the engineering design, a demonstration of licensability and a detailed cost estimate for a demonstration-sized gas-cooled fast breeder reactor. We think the goals of the current phase of the program can be met at a funding level less than 10 percent of a reasonable LMFBR program. For this relatively small increment we believe that this alternative technology which offers the possibility of lower capital cost, higher breeding performance, and advantages in operability and maintainability should be pursued to a point where a more quantitative assessment can be made.

The perceived capital cost advantage of the GCFR cannot be quantitatively assessed until further design work is completed and licensing demonstrated. However, a current assessment of the state of the technology leads us and other independent investigators both in the U.S. and abroad to believe that significant cost advantages may result. The promise of higher breeding performance from a GCFR relative to an LMFBR is quite well accepted by scientists due simply to the fact that helium, which is used as the coolant, allows the operation of the reactor core in an energy range which results in greater nuclear fuel breeding. The value of having a higher breeding ratio is simply that in the future use of breeders fewer plants would be required. With the difficulties perceived in the future siting of breeder power plants, possibly to the extent that they may be contained in high security energy parks, the need for fewer breeders might well be significant. Further, because helium is noncorrosive, chemically inert and does not become radioactive, operation and maintenance appears to be simpler. The very fact that the GCFR does not require an intermediate heat transfer loop, provides not only a part of the capital cost savings, but allows simpler operation of the nuclear system as well.

The segment of the utility industry supporting HBA and the development of the GCFR, which constitutes about thirty percent (30%) of the electric generating capacity in the United States, was surprised and deeply concerned to find that the Administration did not provide funds for its continuance. The program has evolved over a number of years as a joint industry/government effort. Assurances provided by the Administration and the Department of Energy led us to believe that the alternative breeder technology development program was still a part of the overall Administration's nuclear policy. We are not aware of any stated policy change.

The recent history of the GCFR has been one of partnership; HBA representing the utility industry and the federal government. That history should be reviewed briefly to put into context the feeling of betrayal by this budgetary action. The utility industry began supporting research in the GCFR during 1965. This informal utility group provided program direction with ad hoc committees until 1976. These utilities then incorporated the nonprofit HBA at the urging of the government to provide an entity for contracting purposes. Immediately, ERDA awarded a contract to perform a study on the commercialization of the GCFR. HBA subcontracted with independent subcontractors to perform the study. This study has been the basis which HBA has used to formulate its program direction.

When President Carter made his Energy Policy Statement in April 1977, HBA sought assurance that the government policy would continue to support both HBA and the GCFR. ERDA did provide such assurance in the most positive way in a letter to HBA management.

Later in 1977, HBA's response to ERDA's request for a GCFR program manager was accepted. A sole-source justification followed allowing the then DOE to contract with HBA noncompetitively. The sole-source justification was doubly important because it also indicated the government's acceptance of the multi-year program definition and licensing phase (PDLP). HBA placed great confidence in this document due to its final approval by the Under Secretary of the DOE.

In 1978 HBA, at the request of DOE, prepared a report entitled, "Alternative GCFR Roles and Development Strategies." This report provided justification for DOE's fiscal year 1980 budget submission and was cited by the Administration in its fiscal year 1980 budget submittal to the Congress.

HBA and DOE executed a contract in 1979 again signifying a mutual commitment to the GCFR program. President Carter specifically endorsed the continuation of the GCFR in a letter to Speaker of the House O'Neill. Also, the government published two reports further expressing endorsement of the HBA partnership in the GCFR program. The "Fission Energy Program of the U.S. Department of Energy" was prepared by the Office of the Program Director for Nuclear Energy, DOE, for the House Committee on Science and Technology. The Administration's National Energy Plan II is the second statement expressing support for a "Hedged Breeder Strategy" which is completely consistent with the GCFR program's PDLP.

Due in part to such assurances by the government HBA has been able to increase its membership during 1979 -- a year not noted for increasing support for nuclear activity. Seven new utility members and the first two industrial members have agreed to support HBA and the GCFR with both financial and technical manpower.

Thus the unilateral withdrawal of the federal partner without explanation has taken HBA and its members by surprise. This leaves one and all with an uncertain view of the reliability of further industry-government cooperation in long term projects.

The contractors involved in this program include General Atomic as the prime contractor dealing with the nuclear steam supply system for the gas-cooled fast reactor, General Electric Company's Nuclear Division, and Westinghouse's Advanced Reactor Development Division. In addition, portions of the program are being carried out by a number of engineering firms around the country including Bechtel, Stone and Webster, Gilbert Commonwealth, Brown and Root, Parsons and others. Much of the research and development effort is being done at Oak Ridge National Laboratory, Argonne National Laboratory, Pacific Northwest Laboratory, EG&G at the Idaho National Engineering Laboratory, Los Alamos Scientific Laboratory, and Brookhaven National Laboratory. We also have member utilities from foreign countries and through cooperative arrangements work on the GCFR program is being performed in Switzerland, Germany and Belgium. The technology is also enhanced by some work being done in France as a part of their national breeder effort. We believe that if the U.S. took a more aggressive posture with respect to the GCFR, even more significant cooperative arrangements could be made with foreign countries in support of the overall breeder program. Many countries who participate along with the U.S., on the GCFR Coordinating Committee of the Organization for Economic Cooperation and Development, look to this country for leadership in the GCFR development.

The growing support of the GCFR program over the last several years coupled with the increased industry participation has provided us with a significant momentum which can pursue the development of the GCFR technology in an aggressive, well managed way. Several important programmatic milestones have been achieved during FY 79 and 80. A reexamination of design alternatives was concluded with a joint effort undertaken on the part of American and German engineer designers The design was revised in such a way that it incorporates the best thinking of both countries and emphasizes additional safety features. The program has adopted design changes which allow reactor core cooling capability through natural convection processes in the event of the highly unlikely loss of capability in several other redundant cooling systems. This design achievement which results in a significant contribution to even greater safety consideration stands as a tribute to the cooperative arrangements that we have enjoyed with our foreign counterparts. These new features and concepts are now being embodied in the design effort and a complete conceptual design package will be documented and published at the end of FY 80.

Another significant aspect of the PDLP is the design verification effort which utilizes facilities which will demonstrate component performance. For example, over $16 million has already been spent on the Core Flow Test Loop now under construction at the Oak Ridge National Laboratory in Tennessee. The initial facility will be completed in FY-81 and will provide assurances of many design parameters. We have also completed conceptual design of a $31 million Circulator Test Facility which HBA's staff has recommended be built in a facility not now in use at the Idaho National Engineering Laboratory. The utilization of a currently existing facility is consistent with HBA's philosophy of cost effective management. Preparation of the construction proposal, schedule 44, will be completed this year.

When we at HBA began to hear rumors that the GCFR would not be included in the Administration's FY 81 budget request, we sought and received a meeting with the then Under Secretary of the Department of Energy. In that meeting the Under Secretary assured us that there was no expressed policy change regarding support for the GCFR as an alternate breeder technology, and indicated he would reinstate some support for the program in the budget request; but it appears that his efforts were unsuccessful. If this joint industry/government partnership effort is to be dissolved unilaterally by the government, it will stand as yet another example of this governments inability to work cooperatively with industry. In addition, it is likely that we will never regain the position of leadership that we now enjoy worldwide with respect to gas-cooled fast reactor technology. This technology will likely be lost and its promises of lower costs to the customers of electric energy in future generations will not have been given proper investigation. I therefore urge your support of our request for reinstated funding for the GCFR program. Our program plan would have called for funding at a level in excess of $40M for FY 81. However, the program can be pursued and advanced, and our utility membership maintained if funding is restored at least at the $26M level of the current year, plus some allowances for inflation.

Finally, I would like to mention the more subtle implications for the nuclear industry, the utility industry and for the public if well established R&D programs such as this are abruptly dropped for reasons not related to their prospects for success. I have already alluded to the problems which perceived bad faith might cause in future industry/government cooperatives efforts. Any cooperative program with the government dependent as it is on future appropriations is difficult for industry at best. Any additional negative elements will make it even more difficult to attract private sector support for these programs.

When the utilities embarked on the nuclear age almost thirty years ago, it was generally assumed that the nuclear fuel cycle would be completed as a matter of high national priority. It was expected that reactors would improve with research and experience and that waste management, fuel breeding and reprocessing were problems awaiting only development of the best technical and safety approach. In short it was generally accepted that the political and technical uncertainties would be resolved readily.

How wrong we were. Today the greatest uncertainty of all is that of public confidence. No matter how good the technology may be or how good the safety record of the industry or how promising the prospects for meeting our future energy requirements, the nuclear industry and the utilities building or operating nuclear plants frequently wind up being damned as proponents of some sinister self-serving technology that is almost certain to injure or damage the public. The risk that a small minority will be able to mobilize resistence capable of shuting down either the construction or operation of such plant is very high. The extremely high financial risk to companies undertaking nuclear projects is due much more to this uncertainty than technological difficulties. These uncertainties have already led to dramatic reductions in orders of light water reactors and will almost certainly lead to the demise of the nuclear industry if the trend is not reversed. Without vigorous government leadership, this trend will not be turned around and the loss to the country would be critical.

In my part of the country waste management seems to be the matter of greatest concern to the public. This issue is more of a political problem than a technical one, but to the companies entering upon nuclear projects, the fuel cycle is also of critical importance. The large investment in nuclear plants must be amortized over a long period of reliable power production to be economically feasible. Mere speculations that enough natural uranium will be found is not sufficient assurance to justify the tremendous investment necessary to construct and operate those plants. The availability of a safe reliable breeder is of vital importance to the country's energy future. The U.S. has already lost the lead in developing LMFBR technology; let us not loose our present leadership in the gas cooled breeder technology as well. If the time comes when this country has critical need to breed nuclear fuel for power generation, as we sincerely believe it will, let us know that our own technology will be sufficiently developed to meet that need. If the GCFR and the HTGR programs remain unfunded in this budget, the U.S. will probably never regain the position of world-wide leadership we now enjoy with respect to gas cooled reactor technology. That technology and our substantial investment in it would be lost and its possible benefits in terms of lower cost to customers and more efficient use of resources in future generations would not have been given proper investigation.

I urge you to support our request for reinstatement of funding for this program. The project licensing and definition phase which I previously mentioned would have called for funding at a level slightly in excess of $40M for fiscal year 81, but it can be pursued and advanced on a stretched out basis and our utility membership maintained if funding is restored to at least the $26M level of FY 80 with some allowance for inflation.

Thank you very much for the opportunity to present this testimony. I request that my complete statement be included in the record along with the attachments.

TABLE 1

BOARD OF DIRECTORS

Ralph M. Davis
Chairman
Puget Sound Power
& Light Company

Keith W. Amish
Rochester Gas & Electric

William H. Dickhoner
Cincinnati Gas & Electric Co.

Ed Fischer
Pub. Util. Dist. No. 1, Clark Co.

Robert F. Gilkeson
Philadelphia Electric Co.

L.E. Gross, Jr.
Medina Electric Coop., Inc.

Arthur Hauspurg
Consolidated Edison Co. of N.Y., Inc.

Richard O. Newman
Pub. Serv. Co. of Oklahoma

Robert T. Person
P.S. Co. of Colorado

William S. Robson
So. Tex.Elec. Coop., Inc.

Lelan F. Sillin, Jr.
Northeast Utilities

Robert I. Smith
P.S. Electric & Gas

W.S. White, Jr.
American Electric Power Serv. Corp.

Harold L. Williams
Cleveland Electric Illuminating Co.

OFFICERS

Robert S. Hunter
President

John J. Scoville
Vice President &
General Manager

Frank E. Dotson
Treasurer

Wayne C. Booth, Jr.
Secretary

James M. Kruthers
Assistant Secretary

TABLE 2

HELIUM BREEDER ASSOCIATES
1979 Membership and Support

COOPERATIVES (CLASS I)

- Bandera Electric Coop., Inc.
- Cherokee County Electric Coop. Assoc.
- Guadalupe Valley Electric Coop. Assoc.
- Medina Electric Coop., Inc.
- South Texas Electric Coop., Inc.
  - Jackson Electric Coop., Inc.
  - Karnes Electric Coop., Inc.
  - Nueces Electric
  - San Patricio Electric Coop., Inc.
  - Victoria County Electric
  - Wharton County Electric Coop.
- Surprise Valley Electrification Corp.
- Tri-County Electric Coop., Inc.

INVESTOR OWNED (CLASS III)

- Arizona Public Service Company
- Cincinnati Gas & Electric
- Delmarva Power & Light Company
- East Central Nuclear Group (ECNG)
  - American Electric Power
    - Appalachian Power Company
    - Indiana & Michigan Electric Co.
    - Ohio Power Company
  - Allegheny Power System
    - Monogahela Power Company
    - Potomac Edison Company
    - West Penn Power Company
  - Ohio Edison Company
    - Pennsylvania Power Company
  - Columbus & Southern Ohio Electric Co.
  - Southern Indiana Gas & Electric Co.
  - Cleveland Electric Illuminating Co.
  - Louisville Gas & Electric Co.
- Central and South West
  - Central Power and Light
  - Public Service Co. of Oklahoma
  - Southwestern Electric Power Co.
  - West Texas Utilities
- El Paso Electric
- Empire State Electric Energy Research
  - Central Hudson Gas & Electric Co.
  - Consolidated Edison of New York, Inc.
  - Long Island Lighting Co.
  - New York State Electric & Gas Corp.
  - Niagara Mohawk Power Corp.
  - Orange & Rockland Utilities, Inc.
  - Rochester Gas & Electric Corp.
- Gulf States Utilities
- Indianapolis Power & Light

GOVERNMENTAL (CLASS II)

- Public Utility District No. 1 of Clark County

INVESTOR OWNED (Continued)

- Northeast Utilities
  - The Connecticut Light & Power Co.
  - The Hartford Electric Light Co.
  - Holyoke Water Power Company
  - Western Massachusetts Electric Co.
- Philadelphia Electric Company
- Public Service Company of Colorado
- Public Service Electric & Gas
- Public Service of New Mexico
- Puget Sound Power & Light Company
- Southwestern Public Service Co.
- Union Electric Company
- Washington Water Power Company

FOREIGN (CLASS IV)

- ELSAM - Denmark
- AB Kaernkraft, AKK - Sweden
  - AB Bergslagens Gemensamma Kraftforvaltning
  - Balforsens Kraft AB
  - Gullspangs Kraft AB
  - Krangede AB
  - Stora Kopparbergs Bergslags AB
  - AB Svarthalsforsen
  - Sydkraft AB
  - Voxnans Kraft AB
  - Varmlands Kraft - O/G delagarna AB

INDUSTRIAL (CLASS V)

- Brown & Root
- Gilbert Commonwealth

Senator **Matsunaga**. Thank you very much, Mr. Davis.

Dr. Agnew, as you know, there is now discussion about starting work on a new large fusion project called the engineering test facility. Do you think we are ready to start design of the facility this year?

Dr. **Agnew**. Mr. Chairman, I believe that we are. I think there has been continued progress for the past 30 years in the fusion business, and I think that we are going to have to take a step into a large facility and I think the time is now. I don't think it should be continually postponed.

Senator **Matsunaga**. What is your projection on fusion?

Dr. **Agnew**. I don't understand.

You say the projection of fusion?

Senator **Matsunaga**. When we will be able to use nuclear fusion as a way of producing energy rather than nuclear fission.

Dr. **Agnew**. I think if you look back at, let's say, 1942, which is when we first brought in fission, and see where we are today, and then realize that in the field of fusion we have yet to really—what they call—break even, getting the temperature, the density, and confinement such that there is as much energy coming out of the fusion reaction of the machine as you put in—I think then in the next couple of years we could reach that stage, then I think it will be another 20 years before you see commercial application of fusion, and it might be 30. But if we don't have a project and get going now with such a thing as the ETF, it will be just pushed further and further into the future.

Senator **Matsunaga**. What do you think the impact of stopping our HTR program would be on programs in West Germany and Japan?

Dr. **Agnew**. I think it would be rather devastating. Last November we signed an agreement with the Germans in particular on the HTGR program and now 2 months later, when the President's budget went in to renege it, I think it is a serious diplomatic slap to the Germans and I think this was made clear by our Ambassador at large on proliferation in the State Department, a strong proponent of the HTR program, and the totality of the programs, he made a strong recommendation that this should continue to be supported.

The Japanese are aware that the Government has decided to go for a very ambitious HTR program to process heat. That program is just starting. They are looking forward to negotiating with the American Government for an umbrella agreement so technology can be exchanged, and if our program is zeroed out, we lose that.

I think it is a very bad decision on the part of the OMB, and I think that Dr. Deutch and those that have followed his programs support my feelings.

Senator **Matsunaga**. Of course, one of the concerns about any joint effort with Japan, the Phillipines, Taiwan, and South Korea would be the disposal or deposit of nuclear waste matter in U.S. territory.

And my deep concern, being from Hawaii, is that the storage of nuclear waste matter in any of the Pacific islands will lead to some disastrous consequences.

What are we going to do with the nuclear waste?

As I understand it, we have an agreement that we are going to take care of the waste storage.

Dr. **Agnew**. Senator, I sincerely believe that the waste problem is a very simple problem. It is a very emotional problem. It is a political problem that gentlemen such as yourself have to face with the electorate, but I think with the proper education and understanding, people will realize that first the magnitude of the waste is very small.

If all the electric energy in the United States were generated through nuclear power, the total accumulated waste through the end of the century would cover one football field to 20 feet high.

If you visited New Mexico, we have acreage there where one could put this material above ground even, with no risk to the public. If you will explore what happened in Africa 3 billion years ago, when one of the first natural chain reactions took place, you will find that a reactor, because of the concentration of uranium and the presence of water, it went critical by itself, and it went for 100,000 years, and after 100,000 years of operation produced a tremendous amount of this so-called waste.

Those wastes are still there. This is an interesting story. It is in the July 1976 Scientific American. They have gone back and found that the wastes are still there. The wastes do not migrate. If the Earth could do that by itself 2 billion years ago, I assume you, Senator, rest assured, that with the technology we have today we can certainly assure that the wastes, which are very finite in volume, compared to the wastes from coal, more radioactive and much more poisonous, that this small volume of waste can be handled with the technology today.

We have been storing wastes from the military program. France is storing wastes, and the United Kingdom is processing waste. I think we should set up facilities to properly handle the wastes over the world and I would urge that the United States be a party to such an organization.

Senator **Matsunaga**. Do you think the type of accident at Three Mile Island could happen with a high-temperature gas reactor?

Dr. **Agnew**. No, I don't. In fact, I would like to read you something, sir.

Commissioner Hendrie, of the Nuclear Regulatory Commission, on March 7, testifying before the Energy Environmental Subcommittee of the House Interior and Insular Affairs Committee, made a plea for funding to examine the safety and licensing of these types of reactors.

He said:

> I would now talk about the thermal high-temperature gas-cooled thermal machines on the steam electric cycle. They have efficiency as good as the best possible fuel plants. They were substantiall more efficient than the water-cooled reactors. They get better energy utilization out of each pound of uraniun that is mined, better, in fact, by probably 15 or 20 percent even than the best estimates for advanced lightwater improved fuels that we are now doing research on.
>
> I think overall they have safety advantages. They are machines in which you don't have to do a lot of things in a hurry if something goes wrong because the core structure is a massive pile of graphite. So that if you get a power drop off or the plant circulators go out, it is not like a water machine where you have to get diesels started within a minute or you lose things.
>
> You could go home and have a sandwich and watch some television and then come back to the plant and think about what to do. You have literally a couple of

> things before things get very bad, so there are safety advantages, and I am unhappy to see an opportunity for technology that might be lost.

That is an expert who has responsibility for licensing all nuclear plants in this country. When someone of that stature makes a statement showing that you have hours in which to react——

Senator MATSUNAGA. Who is that?

Dr. AGNEW. Commissioner Hendrie, of the Nuclear Regulatory Commission. It has been shown to be true in the Fort St. Vrain reactor where there have been instances where they have had similar initiating circumstances as that at Three Mile Island, but have had plenty of time to assess what to do and have taken that appropriate action.

Senator MATSUNAGA. Dr. Boyer, is the high-temperature gas reactor cost competitive with the lightwater reactor if reprocessing is not done?

Dr. BOYER. Yes. I would say it is. Our estimates show it is in the same range. Until you get one built and operating to get true cost information, you cannot get more definitive data on the subject, but they appear to be in the same cost range.

Senator MATSUNAGA. Given the scale up in the commercial high-temperature gas reactor plant from the 330 megawatt Fort St. Vrain plant, what do you think the licensing time would be compared to a lightwater reactor?

Dr. BOYER. Well, I guess the time required for a lightwater reactor is sort of a variable thing today with the requirements as they exist. The gas-cooled reactor certainly had gone along on a steam cycle, a long way toward being licensed.

In fact, Delmar, Va., Power & Light was about to get a license. We at our Fulton site were well along towards solving the technical problems and making responses to the Nuclear Regulatory Commission in areas that they had. If we move into the gas turbine cycle or into the processed heat breeding, there will be additional time required to resolve those issues to educate the Nuclear Regulatory Commission in those areas, so there could be some additional time in licensing that project.

I would like to add that I would second the remarks of Dr. Agnew with regard to waste disposal and with regard to the safety of the gas-cooled reactor plants. I have looked from the utility industry's viewpoint at the waste disposal issue.

We feel that the Government should get on with demonstration of the proposal. I think the various reports which have been made from the studies on the waste issue have all verified the fact that it is not a technical problem, per se. Canada has had wastes stored at Chalk River for the last 25 years.

As Dr. Agnew mentioned, some of the other nations are underway in a program. We need to get underway so we can get firm data back to aid us in an ongoing program.

Senator MATSUNAGA. Do you think the private industry ought to take the initiative in providing some safe means of storage?

Dr. BOYER. Well, private industry is looking to see what they can do to help accelerate the matters.

Senator MATSUNAGA. Do you feel that the Federal Government ought to take the initiative?

Dr. **Boyer**. The Federal Government has taken the responsibility for the long-term storage of waste, and I think that is the proper place for that responsibility to be.

I think the utilities are certainly willing to work with the Government on developing some programs to achieve the end result, though, and that is the long-term storage of the waste.

Senator **Matsunaga**. Dr. Boyer, do you believe that the utilities will make the commitment to fund construction of a full scale commercial demonstration plant if the Federal Government funds the design work?

Dr. **Boyer**. We are moving in that direction to establish this lead project, which would basically get at least a tentative commitment so that specific studies could be made for a plant at a specific site.

Yes, I think the number of utilities or members of Gas- Cooled Reactor Associates indicate their support for this concept.

Senator **Matsunaga**. Mr. Davis, what is the minimum level of funding needed to maintain the specialists currently working on the gas-cooled breeder reactor?

Mr. **Davis**. Just on the base technology itself?

Senator **Matsunaga**. Yes.

Mr. **Davis**. I had our staff do a study of that, since my last testimony. If it became necessary to back away from this phase of the program that we are working on now and get back down to base technology, we could keep that alive for $14 million in fiscal year 1981.

This is a risk, though. I am not sure that this would save the industry, the private industry financial support. If the utilities see the Government going to that degree, we would really take a shot at it. Whether we could get all of our members to hang in there remains to be seen, but the pure technology work I think could be carried out in fiscal year 1981 for $14 million.

Senator **Matsunaga**. I note the time is fleeting. I may have some other questions which may be submited to you in writing.

I would appreciate your responding in writing for inclusion in the record so other members of the committee who are not present may inform themselves.

Thank you very much.

Our next panel of witnesses consists of Dr. Robert B. Rosenberg, executive vice president, Gas Research Institute, Chicago, Ill., and Dr. Frank C. Schora, senior vice president, Institute of Gas Technology, Chicago, Ill.

We would be happy to hear from you, Dr. Rosenberg.

STATEMENT OF DR. ROBERT B. ROSENBERG, EXECUTIVE VICE PRESIDENT, GAS RESEARCH INSTITUTE, CHICAGO, ILL.

Dr. **Rosenberg**. Mr. Chairman, I have prepared a full statement and request that it be incorporated in the record.

Senator **Matsunaga**. Without objection, it is so ordered.

Dr. **Rosenberg**. I am Robert Rosenberg, executive vice president of the Gas Research Institute, a not-for-profit scientific research organization that was formed in 1976 to plan, finance and manage an expended gas-related research and development program.

GRI is in the process of implementing a $49.3 million contract R. & D. program in 1980. Equally important, GRI will participate with government agencies and manufacturers in programs totaling approximately $145 million through cofunding.

We expect that this will be expanded into approximately $192 million in 1981.

With that brief introduction of GRI, let me say that I am pleased to have this opportunity to appear before you today to discuss why GRI feels that the development and field testing of important near-term conservation technologies such as onsite fuel cell systems should proceed on an expedited schedule and to lend my support to the development and demonstration of an Eastern coal gasification option.

Before I begin my technical presentation, I want to commend this committee for the very strong support it has provided to the Federal programs initiated by DOE to develop coal-based synthetics and for the leading role this subcommittee has played in accelerating conservation research.

With the formation of GRI, a consolidated and expanded research program in gas conservation and efficient utilization has been initiated. GRI is placing the same emphasis on this research as we have on gas supply R. & D. since it offers a potential for significant reduction in consumption in the near term and has a direct impact on reducing the rate of cost increases to the gas users and ratepayers.

To accelerate the pace of the research program in three of the more near-term efficient utilization projects that could have a direct impact in reducing energy costs, GRI has entered into joint programs with DOE on: residential/commercial heat pumps; the onsite 40-kilowatt fuel cell energy systems; several other efficient utilization project areas, including research in solar gas systems and advanced residential furnaces.

I will speak only about those where there is a problem, but if I may digress for a moment, I have been advised that you have a personal interest in marine biomass. This is one of the more exciting programs that GRI now has underway with the Department of Energy.

We are cooperatively funding it at a $4 million level with DOE and it is progressing well and I am happy to be able to report that to you.

In 1977, GRI entered into a joint program with DOE to fabricate, install, evaluate and test in GRI member utilities' services areas, 50 phototype fuel cell systems. This joint effort was initiated simultaneously with continuing technology development work in recognition of the large potential that fuel cells have in saving gas in the residential/commercial market by the late 1980's.

DOE, utilizing $9.5 million authorized by this committee in fiscal year 1981, will start the initial fabrication and GRI will coordinate the gas utilities' funding and field testing of the 50 units.

GRI has budgeted $3.2 million in 1981 to continue the field test and is coordinating a gas utility commitment of approximately $15 million over the next 3 years. DOE has not requested funds to continue the field tests in its fiscal year 1981 budget, but instead has established a fuel cell task force to examine the entire program.

The task force report is complete and has recommended $10 million in fiscal year 1981 for the DOE share of the field test program. This committee will need to authorize a minimun of $10 million in fiscal year 1981 if DOE is to meet its commitment and keep the field test program on schedule.

We feel that the field test phase of the program is crucial in keeping the gas utilities involved in fuel cell development. To date, GRI has obtained commitments from 22 utilities to participate in these field tests at a cost to each utility of approximately $300,000 to $500,000 per installation. These utilities have started ordering equipment and making final site selections for installations in their service areas.

Therefore, it is essential that the DOE fiscal year 1981 funds be available as planned if the program is to succeed.

One additional project area in which GRI is funding research is industrial heat pumps. Due to the inefficiencies of many of the processes that are employed by industry today, the potential to conserve energy is large. For example, an industrial gas-fired heat pump can produce steam from waste heat with a COP as high as 1.8, compared to the 80 percent efficiency of modern boilers. This indicates that 100 percent efficiency improvement is possible.

GRI has budgeted $1 million in fiscal year 1981 for this research and would like to initiate a joint program with DOE. However, none of DOE's current research efforts in industrial heat pumps involve a natural-gas-fired prime mover.

Since 40 percent of industrial energy is provided by natural gas, it is important to initiate research to use gas more efficiently. A minimum of $3 million is needed to be added to the DOE conservation budget in fiscal year 1981 by this committee if a significant research effort in gas-fired industrial heat pumps is to be started.

I would like to explain my views on the role that the development of synfuels can play in helping meet national self-sufficiency goals within the framework of a minimum cost and minimum environmental impact strategy. Specifically, I would like to address the critical role that the rapid development and demonstration of advanced processes to utilize the nation's vast resources of Eastern caking coal must play in a truly national synfuel program.

Without a valid eastern coal option, it probably will not be possible to sufficiently develop the uranium, oil shale and noncaking coal deposits located in the western Great Plains and Rocky Mountains to meet U.S. goals and needs. Development of all of these western reserves at the same time will lead to intensive competition for scarce water, labor, materials and infrastructure resources and possibly prevent the synfuel option from being fully developed and implemented.

It is essential that the resources in the East be developed and utilized because, one, the recoverable coal resources in the East are as great as those of the West.

Second, water is much more available in the East.

Third, markets are closer to points of production in the East.

Fourth, the skilled manpower pool and manufacturing resources are much greater in the East.

Five, the West cannot be expected to be burdened with all of the environmental and socioeconomic problems of synfuels development.

GRI's proposed approach, including a fully funded DOE demonstration plant program, will allow these advantages to be affirmed.

Another important consideration in developing an Eastern coal synfuel option is that most of the advanced processes under development in the DOE fossill program offer the potential of the following advantages over current state-of-the-art technology: one, more efficient utilization of resources through higher process efficiencies; two, 15 percent to 20 percent less capital intensive; three, 15 percent to 20 percent reduction in product costs; four, ability to use caking coals and coal fines; and, five, improved process control technology.

The specific actions that is required in the DOE fiscal year 1981 coal gasification budget to allow these critical coal gasification demonstration plants to proceed to construction and operation in a timely fashion is the following:

One, authorize the $56 million requested by DOE for the first high-Btu coal gasification demonstration plant.

Two, authorize an additional $56 million for the second high-Btu coal gasification demonstration plant.

Three, authorize an additional $6.3 million to complete a phase zero design for a HYGAS demonstration plant.

In essence, I urge the committee to take the same action this year for full funding of the gasification demonstration plants as it took last year in fully funding the coal liquefaction major pilot plant and demonstration plants.

I also wish to support the administration's request for $20 million in fiscal year 1981 for in situ coal gasification.

This program has reached the stage where it is now essential for DOE to seek industry involvement and financial participation in the program. By approving the administration's request, this committee will allow DOE to proceed with a 5-year research and development program through a cost-shared cooperative agreement which will culminate in a pilot-scale demonstration of underground coal gasification.

The Gas Research Institute is working closely with DOE and is providing $1 million to the program in fiscal year 1980, and will continue to participate in fiscal year 1981 since underground coal gasification offers the potential for utilizing currently unmineable coal contained in steeply dipping beds or in horizontal formations 1,000 feet or more below the surface.

That concludes my formal testimony. Again, I thank the committee for the opportunity to testify and discuss the key role conservation and an Eastern coal gasification option can play in the Nation's synfuels programs.

[The prepared statement of Dr. Rosenberg follows:]

Testimony of Dr. Robert B. Rosenberg
Executive Vice President
Gas Research Institute
Before the
Subcommittee on Energy Research and Development
of the
United States Senate
April 1, 1980

Mr. Chairman and Members of the Committee:

I am Robert Rosenberg, Executive Vice President of the Gas Research Institute (GRI), a not-for-profit scientific research organization that was formed in 1976 to plan, finance and manage an expanded gas-related research and development program. GRI's membership consists of 190 investor and publicly owned companies which transport and distribute gas in interstate and intrastate commerce. Its activities are funded through a mechanism that is subject to an annual review and approval by the Federal Energy Regulatory Commission and, where intrastate sources of gas are involved, also by the cognizant state regulatory commissions.

As Executive Vice President of the Gas Research Institute, I am deeply involved in providing direction to GRI's gas-related research program to provide viable technology for use in solving the energy problem. GRI is in the process of implementing a $49.3 million contract R&D program in 1980 which is a significant increase over its 1979 program of $35.9 million (Exhibit 1). GRI's updated five-year plan, which will be filed with the FERC in June, projects the need for a $68.5 million level of effort in 1981 to provide technical alternatives to solve gas-related problems (Exhibit 2). Equally important, GRI will participate with government agencies and manufacturers in programs totaling approximately $145 million through co-funding in 1980. We expect that this will be expanded into approximately $192 million in 1981 (Exhibit 3). These programs are primarily in the areas of coal gasification, unconventional natural gas, gas-fueled heat pumps, on-site fuel cell energy systems and improved gas appliances

With that brief introduction of GRI, let me say that I am pleased to have this opportunity to appear before you today to discuss why GRI feels that the development and field testing of important near-term conservation technologies such as on-site fuel cell systems should proceed on an expedited schedule and to lend my support to the development and demonstration of an Eastern coal gasification option.

Before I begin my technical presentation, I want to commend this Committee for the very strong support it has provided to the federal programs initiated by DOE to develop coal-based synthetics and for the leading role this Subcommittee has played in accelerating conservation research.

GRI Funding of Gas Conservation

With the formation of GRI, a consolidated and expanded research program in gas conservation and efficient utilization has been initiated. GRI is placing the same emphasis on this research as we have on gas supply R&D since it offers a potential for significant reduction in consumption in the near term and has a direct impact on reducing the rate of cost increases to the gas users and ratepayers. As an example of this commitment to an expanded research program in efficient utilization, GRI has increased the annual funding for these programs from $9.7 million in 1979 to a level of $26.9 million in 1981. Additionally, in the updated five-year R&D plan that GRI is now reviewing with its several advisory bodies, efficient utilization funding in 1982 is projected at $35.1 million or 41% of the total R&D program budget, essentially the same level of funding as for gas supply research.

The GRI Efficient Utilization Program

To accelerate the pace of the research program in three of the more near-term efficient utilization projects that could have a direct impact in reducing the energy costs to gas users, GRI has entered into joint programs with DOE on:

- Residential/Commercial Heat Pumps
- On-site 40 kW Fuel Cell Energy Systems
- A number of its other efficient utilization project areas with DOE, including research in solar gas systems and advanced residential furnaces.

The overall program in residential/commercial heat pumps, which includes $3.0 million from DOE and $5.7 million from GRI, is funding research on four different projects. This research, if successful, could result in a limited field test in 1982 of units that have a co-efficient of performance of 1.2 to 1.6 for heating and 0.5 to 1.0 for cooling. The net result would be that these gas heat pumps could provide both heating and cooling for a typical residence while using less gas than is now used for heating. This would be a major cost savings for gas users.

In 1977, GRI entered into a joint program with DOE to fabricate, install, evaluate and test in GRI member utilities' service areas, 50 prototype fuel cell systems. This joint effort was initiated simultaneously with the continuing technology development work in recognition of the large potential that fuel cells have in saving gas in the residential/commercial market by the late 1980's. DOE, utilizing $9.5 million authorized by this Committee in FY 1980, will start the initial fabrication and GRI will coordinate the gas utilities' funding and field testing of the 50 units. GRI has budgeted $3.2 million in 1981 to continue the field test as planned and is coordinating a gas utility commitment of approximately $15 million over the next three years. DOE has not requested funds to continue the field test in its FY 1981 budget but instead has established a fuel cell task force to examine the entire fuel cell program. The task force report is complete and has recommended $10 million in FY 1981 for the DOE share of the field test program. This Committee will need to authorize a minimum of $10 million in FY 1981 if DOE is to meet its commitment and keep the field test program on schedule.

We feel that the field test phase of the program is crucial in keeping the gas utilities involved in fuel cell development. To date, GRI has obtained commitments from 22 utilities (Exhibit 4) to participate in these field tests at a cost to the utility of approximately $300,000 to $500,000 per installation (an installation consists of two 40 kW on-site fuel cell energy systems). These utilities have started ordering equipment and making final site selections for installations in their service areas. Therefore, it is essential that the DOE FY 1981 funds be available as planned if the program is to succeed. In summary, the use of natural gas in on-site fuel cell systems provides a major opportunity for demonstration of improved efficient utilization systems.

One additional project area in which GRI is funding research is industrial heat pumps. Due to the inefficiencies of many of the processes that are employed by industry today, the potential to conserve energy is large. For example, an industrial gas-fired heat pump can produce steam from waste heat with a COP as high as 1.8 (as has been demonstrated with presently operating German equipment), compared to the 80% efficiency (COP 0.8) of modern boilers. This indicates that 100% efficiency improvement is possible. Among the many possible applications for gas-fired industrial heat pump systems, agricultural drying operations (especially grains) and textile finishing are two of the most attractive.

Industrial heat pumps differ considerably from residential and commercial heat pumps in that they must operate at higher temperatures and higher capacities and, therefore, must be larger and incorporate advanced fluids rather than freon as presently used. Addressing those needs requires programs to improve heat pump fluids, mechanical equipment and establishing a technology base. GRI has budgeted $1 million in FY 1981 for this research and would like to initiate a joint program with DOE. None of DOE's current research efforts in industrial heat pumps involve a natural gas-fired prime mover. Since 40% of industrial energy is provided by natural gas, it is important to initiate research to use gas more efficiently. A minimum of $3 million is needed to be added to the DOE Conservation budget in FY 1981 by this Committee if a significant research effort in gas-fired industrial heat pumps is to be started.

Synfuel Options

Now I would like to expand my views on the role that the development of synfuels can play in helping meet national self-sufficiency goals within the framework of a minimum cost and minimum environmental impact strategy. Specifically, I would like to address the critical role that the rapid development and demonstration of advanced processes to utilize the nation's vast resources of Eastern caking coal must play in a truly national synfuel program. Without a valid Eastern coal option, it probably will not be possible to sufficiently develop the uranium, oil shale and non-caking coal deposits located in the Western Great Plains and Rocky Mountains to meet U.S. goals and needs. Development of all of these Western reserves at the same time will lead to intensive competition for scarce water, labor, materials and infrastructure resources and possibly prevent the synfuel option from being fully developed and implemented.

While the Administration's program is under revision by Congress at this time, the overall production goal will probably continue to be in the range of 1.75 million to 2.0 million barrels per day oil equivalent by 1990 to 1992. Therefore, the program continues to be production oriented with a goal that will be extremely difficult to achieve since it is based on financial incentives which will require industry to rely on proven processes that utilize primarily Western coals and oil shale resources.

Each synfuel plant will use several times as much coal as the largest electric generating plant in existence and no plant has ever been built at this scale in the United States. Twenty to 30 of these coal-based plants will have to be built in the next 10 years in either the Western Great Plains or the Southwest in order to meet the President's goals. Additionally, another set of plants which use the same basic heavy construction, engineering and design skills will be required simultaneously for the oil shale program in the same Western sections of the United States. At the same time, the nation will be constructing coal electric plants, many in the Western sections of the country. While it is theoretically possible to achieve a 1.75 to 2.0 million barrels per day production capacity by 1990 to 1992, it is by no means assured and is virtually impossible without an "Eastern coal option."

What, then, is the most technically sound program for the development of synthetic fuels? In my judgement, the program should be divided into two phases, the first phase of which is to demonstrate technical capability and environmental acceptability and the second phase is to develop a production capability. In my opinion, this offers the best chance of success.

Role of DOE Demonstration Plant Program

The key to this phased approach is an accelerated and fully funded Eastern coal demonstration plant program. It is essential that the resources in the East be developed and utilized because (1) the recoverable coal resources in the East — mostly bituminous — are as great as those of the West, which are mostly subbituminous; (2) water is much more available in the East; (3) markets are closer to points of production in the East; (4) the skilled manpower pool and manufacturing resources are much greater in the East; and (5) the West cannot be expected to be burdened with all of the environmental and socioeconomic problems of synfuels development. The proposed phased approach, including a fully funded DOE demonstration plant program, will allow these advantages to be affirmed.

In regard to coal gasification, the Department of Energy has testified that current gasification technology was primarily adapted for the coals located in the West that gasify relatively easily. The Department emphasized that coals found in the Eastern and Midwestern parts of the United States tend to be high sulfur coals that swell and cake thereby impeding the operation of conventional gasifiers. In recognition of this fact, the Department stated:

> "Our RD&D program aims to develop improved processes and process reliability and thereby facilitate using the vast coal reserves in the Eastern United States for synthetic fuels. A successful gasification program not only provides needed sources of gaseous fuels, which can displace oil in residential and industrial uses, but also is central to enhancing the use of indirect coal liquefaction processes."

Another important consideration in developing an Eastern coal synfuel option is that most of the advanced processes under development in the DOE Fossil Program offer the potential of the following advantages over current state-of-the-art technology: (1) more efficient utilization of resources through higher process efficiencies; (2) 15% to 20% less capital intensive; (3) 15% to 20% reduction in product costs; (4) ability to use caking coals and coal fines; and (5) improved process control technology.

Role of Gasification in Synfuel Program

All of the proven commercial processes to convert coal to liquids are based on the indirect liquefaction technology which utilizes synthesis gas as the first major step. The synthesis gas is catalytically converted to produce methanol or Fischer-Tropsch liquids (diesel fuel and gasoline). Therefore, synthesis or medium-Btu gas is key in all near-term indirect liquefaction processes. Additionally, all of the direct liquefaction processes under development in the DOE program use a gasification process to produce hydrogen. This is an essential step in the process. Therefore, gasification is an essential step in converting coal to liquids as well as pipeline-quality gas.

The current DOE coal gasification demonstration plant program has seven processes under development. Five of these plants would produce both high-Btu pipeline-quality gas and medium-Btu fuel gas for several different end-use applications. The processes and equipment would be commercial sized and the plants could later be expanded to full commercial operation. While these plants are all still in the design phase, all of them could be operational by 1984 to 1986 if fully funded as part of a DOE program (Exhibit 5).

The bottom line is that without the DOE coal gasification demonstration plant program fully funded and integrated into the nation's synfuel program, the synfuel gas option will, for the foreseeable future, remain a totally Western option.

DOE FY 1981 Budget Recommendations/Coal Gasification

The specific action that is required in the DOE FY 1981 coal gasification budget to allow these critical coal gasification demonstration plants to proceed to construction and operation in a timely fashion is the following:

1. Authorize the $56 million requested by DOE for the first high-Btu coal gasification demonstration plant (76-1-b).

2. Authorize an additional $56 million for the second high-Btu coal gasification demonstration plant (77-1-b).

3. Authorize an additional $6.3 million to complete a Phase Zero design for a HYGAS demonstration plant.

In essence, I urge the Committee to take the same action this year for full funding of the gasification demonstration plants as it took last year in fully funding the coal liquefaction major pilot plant and demonstration plants.

In situ Coal Gasification

I also wish to support the Administration's request for $20 million in FY 1981 for in situ coal gasification. The Administration has requested $10 million in the line budget and identified an additional $10 million that will be requested from the expected revenues of the proposed windfall profits tax. A $20 million authorization will allow DOE to work actively with industry to ensure that the information developed will be transferred to industry. It will allow DOE to both continue the development of the necessary technology base and provide for the start of a five-year cooperative program with industry that will lead to the first pilot-scale demonstration of underground coal gasification.

During the initial development of this technology, the government relied principally on its national laboratories and energy technology centers to develop the technology through in-house research and field tests. Over the last seven years, DOE has developed an excellent in-house capability by drawing on a variety of laboratories for the diverse disciplines that are necessary to develop underground coal gasification technology. This has led to a series of field tests that have successfully produced low- and medium-Btu gas.

The program has reached the stage where it is now essential for DOE to seek greater involvement and financial participation in the program. By approving the Administration's request, this Committee will allow DOE to proceed with a five-year research and development program through a cost-shared cooperative agreement which will culminate in a pilot-scale demonstration of underground coal gasification. The Gas Research Institute is working closely with DOE and is providing $1 million to the program in FY 1980 and will continue to participate in FY 1981 since underground coal gasification offers the potential for utilizing currently unmineable coal contained in steeply dipping beds or in horizontal formations 1000 feet or more below the surface.

Summary

Successful implementation of a strategy to solve the nation's energy problem requires as two key elements a synfuel option for Eastern coals and an increased awareness and demonstration of more efficient energy utilization systems. To fully address these two high-priority elements in the DOE FY 1981 Fossil and Conservation Programs will require:

- Additional authorization of $10 million for the field test of the on-site 40 kW fuel cell energy system.
- Additional authorization of $3 million for an industrial gas-fired heat pump program.
- Additional authorization of $56 million to fund the second high-Btu pipeline gas demonstration plant (77-1-b).

These actions will provide the resources necessary to keep these programs on schedule.

That concludes my formal testimony. Again, I thank the Committee very much for the opportunity to testify and discuss the key role conservation and an Eastern coal gasification option can play in the nation's synfuels programs. I will be glad to answer any questions you may have.

Exhibit 1

COMPARISON OF 1979 and 1980 R&D PROGRAM AREA ALLOCATIONS

	1979 R&D Budget		1980 R&D Budget	
	($1,000)	Percent of R&D Budget	($1,000)	Percent of R&D Budget
1.0 Supply	20,028	56	22,500	46
2.0 Economics and Systems Research	2,100	6	2,475	5
3.0 Environment, Safety and Distribution	2,100	6	4,485	9
4.0 Efficient Utilization	9,705	27	16,055	32
5.0 Basic Research	1,925	5	3,800	8
Total	35,858	100	49,315	100

Exhibit 2

BUDGET ALLOCATION SUMMARY

	Approved 1980 ($1,000)	Planned 1981 ($1,000)
I. RESEARCH AND DEVELOPMENT	49,315	68,500
Supply Options	26,260	31,625
Near-Term	7,200	10,850
Mid-Term	17,200	18,075
Long-Term	1,860	2,700
Efficient Utilization	16,810	26,950
Near-Term	5,360	7,800
Mid-Term	11,245	18,650
Long-Term	205	500
Enhanced Service	3,920	6,055
Near-Term	3,735	5,755
Mid-Term	0	0
Long-Term	185	300
Fundamental Research (Long-Term)	2,325	3,870
II. TECHNICAL PROJECT MANAGEMENT	1,606	2,201
III. ADMINISTRATIVE AND GENERAL EXPENSES	6,811	8,299
A. Planning and Analysis	1,773*	1,646
B. Public Communications	335	522
C. General Operating Expenses	4,703	6,131
IV. TECHNOLOGY ASSESSMENT GROUP	0	1,500
TOTAL GRI BUDGET	57,732	80,500

*$350,000 from 2.3 (2.3.2 Systems Analysis) moved to Planning & Analysis per FERC Staff Report, 7/23/79

Exhibit 3

PLANNED GOVERNMENT AND INDUSTRY COFUNDING BY ORGANIZATION SUBPROGRAM

	Approved and Expected 1980 ($1,000)			Estimated 1981 ($1,000)		
	GOVT	IND	GRI	GOVT	IND	GRI
1.0 Supply	39,225	0	22,500	45,500	0	27,250
1.1 Unconventional Natural Gas	10,600	0	5,700	20,200	0	10,000
1.2 SNG from Fossil Fuels	23,625	0	13,250	20,000	0	12,220
1.3 SNG from Biomass	5,000	0	3,300	5,300	0	5,030
1.4 Hydrogen	0	0	250	0	0	0
2.0 Economics and Systems Research	2,625	850	2,475	3,000	1,000	3,290
2.1 Economics of Supply Technologies	900	0	1,300	1,000	0	825
2.2 Economics of Utilization Technologies	0	0	450	0	0	600
2.3 Energy Economics	1,725	850	525	2,000	1,000	1,440
2.4 Economics of Gas Operations	0	0	200	0	0	425
3.0 Environment, Safety and Distribution	6,935	340	4,485	15,000	1,200	7,230
3.1 Environment and Safety - Supply	335	50	850	650	0	850
3.2 Environment and Safety - Utilization	0	50	100	100	100	1,050
3.3 Distribution	100	220	1,545	7,650	1,010	2,580
3.4 Environment and Safety - Distribution	6,500	20	1,990	6,600	90	2,750
4.0 Efficient Utilization	31,125	12,690	16,055	35,975	19,305	24,800
4.1 Residential and Commercial Space Conditioning	2,900	2,340	5,400	4,900	2,675	7,750
4.2 Gas Appliances	450	150	1,980	800	400	2,750
4.3 Fuel Cell and Energy Cogeneration Systems	26,500	9,000	2,920	28,000	14,100	6,150
4.4 Industrial Utilization	850	1,150	4,055	1,550	2,000	5,950
4.5 Solar/Gas Energy Systems	425	50	1,700	725	130	2,200
5.0 Basic Research	1,187	467	3,800	1,350	800	5,930
5.1 Long-Term Supply	0	0	1,610	0	0	2,550
5.2 Long-Term Utilization	0	0	205	0	0	550
5.3 Long-Term Enhanced Service	0	0	185	1,350	800	400
5.4 Fundamental Research	1,187	467	1,800	0	0	2,430
Total — Contract Research	81,097	14,347	49,315	100,825	22,305	68,500

Exhibit 4

FIELD TEST COMMITMENTS

Forms Returned

Brooklyn Union Gas
Southern California Gas
Columbia Gas
National Fuel Gas
Northern Illinois Gas
Pacific Gas & Electric
San Diego Gas & Electric
Osaka Gas
Tokyo Gas
Mountain Fuel Resources
Richmond Gas/Phillip Morris
Memphis Gas, Light & Water
Connecticut Natural Gas
Gasco
Georgia Power Co.
Consumers Power
Baltimore Gas & Electric
Atlanta Gas Light
Northwest Natural

Verbal

Consolidated Edison
Public Service Electric & Gas
Florida Power

Exhibit 5

PROJECT TITLE	TECHNOLOGY	ENGINEER	SCALE COAL TPD	COST $ Million (1979 Dollars)	SCHEDULE	LOCATION	GOVERNMENT FUNDING ROLE	CURRENT STATUS OF TECHNOLOGY	FUNDING STATUS
DOE Demo Program									
1. High-Btu Gas (Conoco)	BGC-Lurgi Slagger	Foster-Wheeler	1250 19MM SCFD SNG	37 Design 380 Total	Des. compl. mid '80 Const. compl. mid '84 Op. thru mid '87	Noble County, Ohio	Design 100% DOE, Const. & operation 50/50 industry/DOE.	300 TPD unit in Scotland 5 day runs on Pittsburgh 8 & Ohio 9 in 1978 including 23% fines in top feed.	Current DOE posture is to select one of these two projects in spring 1980 for construction.
2. High-Btu Gas (ICGG Illinois Coal Gasification Group)	COED-COGAS	Dravo	2210 23MM SCFD SNG 1120 BPD Fuel Oil 360 BPD Naphtha	32 Design 580 Total	Des. compl. mid '80 Const. start early '81 Const. compl. mid '84	Perry County, Illinois	Design is 96% DOE. DOE to fund 50% of construction and operation.	200 hour run on COED char in 50 TPD COGAS unit at NCB-CURL (Leatherhead) in 1978.	
3. High-Btu Gas HYGAS/Ken-Tex	IGT-HYGAS	Bechtel, Inc.	7340 63MM SCFD SNG	17.5 Design 660 Total	Non-site-specific des. compl. Further plans not yet defined.	Western Kentucky	DOE funded 100% of design. Original proposal based on HYGAS not selected by DOE for High-Btu demonstration.	75 TPD pilot plant in Chicago. Operated on lignite, subbituminous and bituminous coals. 178 hr. run on Ill. 6 run-of-mine coal.	DOE plans unknown at this time.
4. Industrial Fuel Gas (Memphis LG&W)	IGT-U-Gas	Foster-Wheeler	3160 179MM SCFD of 300 Btu/SCF fuel gas	6.5 Design 260 Total	Des. compl. early '80 Const. start '80 Const. compl. '83	Memphis, Tennessee	Design 100% DOE. DOE to fund 50% of construction and operation.	22 TPD unit in Chicago. 7 day run on Kentucky 9 in early 1979.	DOE selected for construction.
5. Industrial Fuel Gas (W. R. Grace)	Texaco	Ebasco, Humphrey's Glasgow	1700 1200 TPD Ammonia	11.6 Design 233 Const. 75 Op. 320 Total	Des. compl. early '80	Baskett, Kentucky	Design 100% DOE. DOE to fund 50% of construction and operation.	150 TPD unit at Ruhrchimie operated since January 1978. Similar size unit at DOW currently in start-up.	DOE to fund indirect liquefaction conceptual design.
6. Fuel Gas-Utility (American Electric Power)	Esso CAFB (Chemically active fluid bed)	Foster-Wheeler	1150 TPD Retrofit	Not yet defined	Not yet defined. No contract yet negotiated.	Cabin Creek, West Virginia	RFP proposed. Design 100% DOE. Construction & operation 50% DOE.	5 TPD unit at ESSO in England. 15 MW unit at Central P&L	Selected by DOE for contract negotiation in May 1978 but negotiations not yet started.
7. Fuel Gas-Utility (Gulf States Utilities)	Combustion Engineering	Combustion Engineering	150 MW Retrofit	Not yet defined	Not yet defined. No contract yet negotiated.	Lake Charles Louisiana	RFP proposed. Design 100% DOE. Construction & operation 50% DOE.	120 TPD pilot plant in Windsor, Connecticut. Approx. 2000 hours operation at 75% load.	

Senator **Matsunaga**. Thank you very much, Dr. Rosenberg. There is a vote now in progress on the floor, so unless—will you be making a statement also?

Dr. **Schora**. Yes, sir.

Senator **Matsunaga**. How long will your statement be?

There is the 5-minute signal, so I will have to go vote and I will be right back.

[Recess.]

Senator **Matsunaga**. Dr. Schora, we will be happy to hear from you.

STATEMENT OF DR. FRANK C. SCHORA, SENIOR VICE PRESIDENT, INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL.

Dr. **Schora**. Thank you, sir.

I would like to submit a longer form of my testimony for the record.

Senator **Matsunaga**. Without objection, your written testimony will appear in the record. I would appreciate your summarizing your statement in as short a time as you can, no more than 10 minutes.

Dr. **Schora**. Mr. Chairman and members of the subcommittee, I am senior vice president of the Institute of Gas Technology, a not-for-profit scientific research organization affiliated with Illinois Institute of Technology in Chicago.

IGT has specialized in conducting energy research development and demonstration work and energy-related education programs for 39 years. I am pleased to provide you today with our assessment of some important energy issues, together with information on several specific technologies for utilizing our fossil energy resources efficiently and in an environmentally acceptable manner.

These technologies can have a major impact on the direction and thrust of the development of our domestic energy supplies.

We believe strongly that synthetic fuels development is of extreme importance in the nation's overall energy and economic future. However, even with the impetus to be provided by measures now under consideration by Congress, little in the way of synthetic fuel production and oil import displacement will be realized before the late 1980's.

We, therefore, urge that those technologies now ready for commercialization should be pushed aggressively in parallel to realize their contribution by the mid-1980's. The more successful would then be further deployed.

We suggest a two-phase approach in implementing the synthetic fuels program now being considered by Congress. The first phase would consist of deploying several commercial plants using currently available technology, while simultaneously deploying demonstration plants for a number of advanced technologies to establish their current commercial viability.

We must investigate the commercial value, through demonstration plants, of all feasible technologies and resources.

The split between synthetic gaseous and liquid fuels should be at least half gases because gaseous fuels can be substituted directly for oil in essentially all stationary applications; they represent a finished product of high form value; and they can be produced at lower cost than liquids from coal.

The following are our recommendations for continuing research, development and demonstration in a number of areas which we feel are most important in achieving national energy goals.

In the area of high-Btu gas, we recommend active funding in fiscal year 1981 for two demonstration plants. These plants are in addition to the administration's support of the Great Plains project that uses Lurgi technology on Western coal. The two demonstration plants will apply advanced technologies on Eastern coal.

Specifically, we recommend that the Department of Energy select, at an early date, one of the two currently competing high-Btu coal gasification technologies for construction under DOE project 76-1-b.

Further, we are in agreenent with the gas industry position that initial funding for a second high-Btu coal gasification demonstration plant should be provided by the Congress in DOE's fiscal year 1981 budget authorization. To select the best technology to be demonstrated in this second plant, we recommend a new competition be held including as candidate technologies, the process not selected in the first round, and other advanced technologies such as the HYGAS process.

This competition, as well as DOE selection of the second high-Btu process to be demonstrated, should be completed in fiscal year 1981. To facilitate such a competition, we should like to point out that Texas Gas Transmission Corp. and the Commonwealth of Kentucky have proposed a phase-zero HYGAS study that would complete the federally funded Procon demonstration plant design by making it site and coal specific.

Among other efforts, the phase-zero study would update the Procon design and would provide for environmental and byproduct marketing studies—all pointing the way for project construction and operation phases.

Clearly, the next logical step in the development of the HYGAS process is the conduct of a phase-0 study. An additional Congressional authorization of $6.3 million is needed for the DOE fiscal year 1981 budget, which when added to the $1.2 million pledged by Texas Gas Transmission Corp. under a cost-sharing arrangement will permit the prompt initiation of phase-0 work.

We understand that Texas Gas Transmission Corp. and the Commonwealth of Kentucky continue to seek construction of the first train—producing 85 million cubic feet per day of pipeline quality gas—of a three-train commercial plant in western Kentucky. And we are told that "upon completion of the demonstration period, Texas Gas Transmission Corp. would purchase the facility and expand it to commercial size".

We are pleased that the Department of Energy has selected the city of Memphis' light, gas, and water division's proposal to design, construct and operate an industrial fuel gas demonstration plant based on the IGT developed U-GAS process.

The U-GAS process is capable of producing clean, environmentally acceptable medium-Btu gas from any U.S. coal for use in industry. The process features simple design and reliable operation and offers industry a fuel to solve their present dilemma: having to choose between natural gas which can be interrupted, imported oil whose price is rising fast, or the direct burning of coal with its associated environmental constraints.

In the form of synthesis gas, the U-GAS product may be used—in addition to its use as fuel—directly as a chemical feedstock for the production of hydrogen, ammonia, or methanol or liquid fuels.

Pressurized, the gas is suitable for advanced electric power generation systems such as combined gas turbines/steam turbine cycle, a fuel cell, or a magnetohydrodynamic generator.

Pending the early completion of cost-sharing negotiations between DOE and Memphis light, gas, and water division, construction of the plant could begin by this fall with plant operation underway by 1984. The plant would convert 3,100 tons of Kentucky No. 9 coal each day into 154 million cubic feet of industrial fuel gas.

We urge the Congress to support DOE's anticipated supplemental budget request for fiscal year 1981 to provide for the Government's share in the first year of this vital program which will help meet the Nation's future energy needs.

We urge your support of the DOE budget request of $13 million for fiscal year 1981 for continued development of peat gasification and related activities and consider it appropriate to realize the potential of peat gasification to enhance our national energy supply. Funding at this level will provide for a year's operation of the HYGAS pilot plant using peat feedstock, further improvement of methods to dewater peat, and the further assessment of both national peat resources and the environmental impact of peat utilization.

Modifications to the HYGAS pilot plant for the processing of peat are to begin soon so that operations can begin promptly in fiscal year 1981. We wish to stress that the modifications and subsequent operations of the pilot plant on peat will not interfere with the phase-0 program for demonstration of HYGAS.

Eastern oil shale exists in a number of States, including Ohio, Kentucky, Tennessee, Indiana, Michigan, and Alabama. The surface mineable reserve for these six States is conservatively estimated to be 423 billion barrels of shale oil.

The IGT HYTORT process converts and recovers the shale oil as gaseous and liquid products by retorting with hydrogen. As described in testimony last year, the HYTORT process is applicable to both Eastern and Western shales.

Because of the hydrogen treatment, the HYTORT product oil is a light, high quality oil which will yield No. 2 distillate, jet fuel, and lighter products.

The hydrocarbon recovery is particularly enhanced in eastern shale, making this vast resource economically recoverable. We presently estimate that an oil price of high quality—low nitrogen—low sulfur feedstock will be $27 to $29 a barrel based on first quarter 1980 dollars.

The activity to date continues to confirm that the cost of fuels will be competitive with imported oil. Clearly, we appreciate the congressional initiative in recognizing the sizeable Eastern oil shale resource and the need for the development of this technology. We are working with both DOE and industrial firms to pursue early commercialization of this promising technology.

For the past 3 years, IGT has been investigating an approach to the rapid pyrolysis of coal in a hydrogen environment that permits the sinultaneous extraction of valuable oil and gas products without forming a heavy, hard-to-handle tar at the same time.

The goal of this work, which has been sponsored by the Department of Energy, is a multiproduct process that will provide high octane gasoline blending stock, light aromatic fuel oil, petrochemical feedstock, and substitute natural gas.

Our preliminary estimates of the production costs of these products with utility financing are $3.70 per thousand cubic feet for natural gas, 85 cents per gallon for gasoline blends, and 65 cents per gallon for light fuel oils.

Stimulated by the growing need for reliable and economic synthetic fuel production processes, IGT has recently reviewed our development program for this process we call HYFLEX and concluded that acceleration is possible. Funding in the amount of $3.5 million will permit us to continue and accelerate the process development unit work, not only to continue verification of the process, but also to develop the data necessary for the design of a HYFLEX pilot plant with which to confirm and optimize future commercial unit designs.

Preliminary design of a HYFLEX pilot plant to process 100 tons of coal per day would be undertaken and procurement of major long delivery equipment items initiated. Operation of the pilot plant will be targeted for 1983, and commercial demonstration might be undertaken by as early as 1985.

Further, should our experience prove as favorable as we anticipate, HYFLEX could become a very attractive candidate for addition to our national synthetic fuels production capability, to be established by the Energy Security Corporation, in the latter half of this decade.

I appreciate very much the opportunity to present our viewpoints to the subcommittee, and will be happy to answer any questions you may have concerning this testimony.

Thank you.

[The prepared statement of Dr. Schora follows:]

Statement by Frank C. Schora, Senior Vice President
Institute of Gas Technology
Before the Senate Committee on Energy and Natural Resources,
Subcommittee on Energy Research and Development
Fiscal Year 1981 Budget Authorizations

April 1, 1980

Mr. Chairman and members of the subcommittee:

I am Senior Vice President of the Institute of Gas Technology, a not-for-profit scientific research organization affiliated with Illinois Institute of Technology in Chicago. IGT has specialized in conducting energy RD&D work and energy-related education programs for 39 years. I am pleased to provide you today with our assessment of some important energy issues, together with information on several specific technologies for utilizing our fossil energy resources efficiently and in an environmentally benign manner. These technologies can have a major impact on the direction and thrust of the development of our domestic energy supplies.

We believe strongly that synthetic fuels development is of extreme importance in the nation's overall energy and economic future. However, even with the impetus to be provided by measures now under consideration by Congress, little in the way of synthetic fuel production and oil import displacement will be realized before the late 1980's. We, therefore, urge that those technologies now ready for commercialization should be pushed aggressively in parallel to realize their contribution by the mid-80's. The more successful would then be further deployed.

We suggest a two-phase approach in implementing the synthetic fuels program now being considered by Congress. The first phase would consist of deploying several commercial plants using currently-available technology, while simultaneously deploying demonstration plants for a number of advanced technologies to establish their current commercial viability. We must investigate the commercial value, through demonstration plants, of all feasible technologies and resources.

The second phase of the implementation of the synthetic fuels program would come in the mid-80's by deploying commercial plants based on demonstrated advanced technologies. The first-phase commercial plants will continue to be feasible because of the cost escalation during the time period that advanced technologies are being demonstrated. These plants will also provide a real reference for production costs, performance and environmental data. The second-phase commercial plants will be more efficient and economic and will be the basis for the competitive growth of the synthetic fuels industry.

The split between gaseous and liquid fuels should be at least half synthetic gases because (a) gaseous fuels can be substituted directly for oil in essentially all stationary applications; (b) gas represents a finished product of high form value; and (c) the cost of gas production is lower than that of liquids when utilizing coal.

Fossil resources in the East must be emphasized strongly because of the large resource base in coal and shale, the availability of water, the proximity of population centers and markets, and the existence of manpower and manufacturing infrastructures. Furthermore, technologies that must be developed for Eastern coals can also utilize Western coals, but the reverse is not true.

The following are our recommendations for continuing research, development, and demonstration in a number of areas that we feel are most important in achieving national energy goals.

SNG FROM COAL

In the area of high-Btu gas, we recommend active funding in FY81 for two demonstration plants. These plants are in addition to the administration's support of a Great Plains project that uses the Lurgi technology on Western coal. The two demonstration plants will apply advanced technologies for Eastern coal.

Specifically, we recommend that the Department of Energy should select, at an early date, one of the two currently competing high-Btu coal gasification technologies for construction under DOE Project 76-1-b. Further, we are in agreement with the gas industry position that initial funding for a second high-Btu coal gasification demonstration plant (DOE Project 77-1-b) should be provided by the Congress in DOE's FY81 budget authorization. To select the best technology to be demonstrated in this second plant, we recommend a new competition be held including as candidate technologies, the process not selected in the first round, and other advanced technologies such as HYGAS®. This competition as well as DOE selection of the second high-Btu process to be demonstrated should be completed in FY81. To facilitate such a competition, we should like to point out that Texas Gas Transmission Corporation and the Commonwealth of Kentucky have proposed a phase-zero HYGAS study that would complete the federally funded Procon Demonstration Plant design by making it site and coal specific. Among other efforts, the phase-zero study would update the Procon design, adapt it to a Kentucky coal and plant site and would provide for environmental and by-product marketing studies — all pointing the way for project construction and operation phases.

The Federal Government and the gas industry have invested $83 million in developing the HYGAS process.

The pilot plant phase of the HYGAS process development program has verified technically and economically all key process concepts, performed reliably as an integrated system, and conclusively proven steady-state operation using feeds varying from lignite to caking high-sulfur bituminous coal feedstocks. IGT and others are fully satisfied that the HYGAS process is the most economic, technically advanced process for the gasification of Eastern, caking bituminous coals. As such, it is ready for and deserving of commercial demonstration.

Various studies have been made in recent years comparing the economics of emerging coal-to-SNG processes. The study conclusions invariably show the second generation HYGAS technology as having substantial technological and cost advantages over first generation processes, and other second generation processes, and that the HYGAS pilot plant program has advanced the joint DOE-gas industry, high-Btu coal gasification program significantly, and on a continuing basis.

Clearly, the next logical step in the development of the HYGAS process is the conduct of phase-zero studies. An additional Congressional authorization of $6.3 million is needed for the DOE FY81 budget, which when added to the $1.2 million pledged by Texas Gas Transmission Corporation under a cost-sharing arrangement will permit the prompt initiation of phase-zero work.

We understand that Texas Gas Transmission Corporation and the Commonwealth of Kentucky continue to seek construction of the first train (producing 85 million cubic feet per day of pipeline-quality gas) of a three-train commercial plant in western Kentucky. And we are told that "upon completion of the demonstration period, Texas Gas Transmission Corporation would purchase the facility and expand it to commercial size."

We are pleased that the Department of Energy has selected the Memphis Light Gas and Water Division's (City of Memphis) proposal to design, construct and operate an industrial fuel gas demonstration plant (DOE Project 76-1-c) based on the IGT developed U-GAS® process. The U-GAS process is capable of producing clean, environmentally acceptable medium-Btu gas from any U.S. coal for use in industry. The process features simple design and reliable operation and offers industry a fuel to solve their present dilemma; having to choose between natural gas which can be interrupted, imported oil whose price is rising fast, or the direct burning of coal with its associated environmental constraints. In the form of synthesis gas, the U-GAS product may be used as a chemical feedstock for the production of hydrogen, ammonia, or methanol. Pressurized, the gas is suitable for advanced electric power generation systems such as combined gas turbines/steam turbine cycle, a fuel cell, or a magnetohydrodynamic (MHD) generator.

Pending the early completion of cost-sharing negotiations between DOE and MLGW, construction of the plant could begin by this fall with plant operation underway by 1984. The plant would convert 3100 tons of Kentucky #9 coal each day into 154 million cubic feet of industrial fuel gas, which is equivalent to 50 million cubic feet of natural gas. We urge the Congress to support DOE's anticipated supplemental budget request for FY81 to provide for the government's share in the first year of this vital program which will help meet the nation's future energy needs.

We also would like to commend Congress and the Department of Energy for their increased recognition and funding for the development of the nation's vast peat resources. U.S. peat resources are estimated to total about 1400 quads (10^{15} Btu), equivalent to over 200 billion barrels of crude oil. Although peat is found in most states, the largest resources are located in parts of Alaska, Minnesota, Michigan, Florida, Wisconsin, Louisiana and North Carolina. Many of these states have no other significant resources of fossil fuels; this enhances the importance of peat development in those areas.

Originally sponsored by the Minnesota Gas Company and then jointly with DOE, our work has shown that this very young coal is converted to gas and liquids more rapidly than any other coal. The peat conversion process uses a relatively simple gasifier, requires less rigorous process conditions than coal gasification, and can handle high moisture content peat. These factors contribute to attractive process economics, indicating that SNG and liquid fuels can be produced at a price competitive with other fuels.

Further, large-scale peat development presents an unprecedented opportunity to transform an area of unused land into a productive wildlife refuge or agricultural area while recovering the energy in the peat as clean-burning SNG.

We urge your support of the DOE budget request of $13 million for FY81 for continued development of peat gasification and related activities. We consider it necessary and appropriate to enhance our national energy supply. Funding at this level will provide for a year's operation of the HYGAS pilot plant using peat feedstock, the further improvement of methods of peat preparation prior to gasification, and further assessment of national peat resources and of the environmental impact of peat utilization.

Modifications to the HYGAS pilot plant for the processing of peat are to begin soon so that operations can begin promptly in FY81. We wish to stress that the modifications and subsequent operations of the pilot plant on peat will not interfere with the phase-zero program for a demonstration of HYGAS.

As a research tool, the flexibility of the pilot plant, in which the HYGAS process was developed, makes possible its modification to feed either peat or coal as desired. Therefore, the peat program can be begun without the delay arising from the need to construct a separate pilot plant facility.

During this past year, IGT has determined the gasification characteristics of peat from North Carolina and Maine and has designed a peat gasification process using North Carolina peat as we have done with peat from Minnesota.

We have undertaken the development of peat dewatering techniques. The wet carbonization method, tested on Minnesota, North Carolina and Maine peat, facilitates mechanical dewatering down to as low as 35% moisture and could be considered a pre-treatment to gasification. We are also conducting tests to determine the technical and economic feasibility of peat dewatering by solvent extraction. We have also investigated in some detail low severity hydropyrolysis of peat to determine the yield and composition of liquid synthetic fuel products.

EASTERN OR DEVONIAN OIL SHALE

Another extensive and virtually untapped U.S. energy resource — Eastern Devonian oil shale — has been further addressed by IGT researchers, through the continued development of our HYTORT™ process which produces both liquid and gaseous synthetic fuels.

Devonian oil shales exist in a number of states, including Ohio, Kentucky, Tennessee, Indiana, Michigan and Alabama. The surface-mineable reserve for these six states was conservatively estimated to be 423 billion barrels of shale oil. The IGT HYTORT™ process converts and recovers the shale oil as gaseous and liquid products by retorting with hydrogen at elevated pressure, using controlled heating rates. Because of the hydrogen treatment, the HYTORT product oil is a light, high-quality oil which will yield a large proportion of number two heating oil and jet fuel and other lighter products. As described in testimony last year, the HYTORT process is applicable to both eastern and western shales. Hydrocarbon recovery with HYTORT is particularly enhanced in eastern shale, making this vast previously unexploited resource economically recoverable.

Activity to date continues to confirm that the cost of fuels will be competitive with imported oil. We appreciate the Congressional initiative in recognizing the sizeable Eastern oil shale resource and the need for the development of this technology. We are working with both DOE and industrial firms to pursue early commercialization of this promising technology.

With the DOE support provided in last year's appropriation, the following accomplishments have been possible:

- Multi-ton samples of representative Eastern shales have been obtained and are being tested to determine the variability of synfuels yields from specific Devonian shale.
- Existing equipment is being modified to test the internal generation of process hydrogen directly from raw or spent shale for use in the reactor. Current IGT process designs use a portion of the gas or liquid products for hydrogen manufacture.
- Other equipment modification has been completed to permit upgrading of raw shale oil to refinery feedstock.
- An environmental engineering firm has been selected to assist IGT in process environmental assessment work to assure the compatibility of the process with the environment.

SNG AND LIQUIDS FROM COAL

For the past three years, IGT has been investigating an approach to the rapid pyrolysis of coal in a hydrogen environment that permits the simultaneous extraction of valuable oil and gas products without forming a heavy, hard-to-handle tar at the same time. The goal of this work, which has been sponsored by the Department of Energy, is a multi-product process that will provide high octane gasoline blending stock, light aromatic fuel oil, petrochemical feedstock, and substitute natural gas. Our preliminary estimates of the production costs of these products with utility financing are $3.70 per thousand cubic feet for natural gas, 85 cents per gallon for gasoline blends, and 65 cents per gallon for light fuel oils.

The heart of the process is a slender vertical reaction chamber, in which the time and temperature of the coal and hydrogen reaction can be carefully controlled to promote cracking of the coal into aromatic liquids, light saturated gas, and a gasifiable char. In conventional chemical plants, when the flow of materials in them is upward, such chambers are called risers. Thus, we refer to the central equipment feature of the process as a "riser cracker".

The results of our work to date, at both the bench and process development unit scale, have been sufficiently rewarding that we have begun conceptualizing a commercial unit. By integrating the riser cracking reactor into an overall coal conversion process we have created what we call the HYFLEX™ process to provide needed liquid and gaseous fuels and chemicals in the coming decades.

Stimulated by the growing need for reliable and economic synthetic fuel production processes, IGT has recently reviewed our development program for HYFLEX and concluded that acceleration is possible. Funding in the amount of $3.5 million will permit us to continue and accelerate the process development unit work, not only to continue verification of the process but also to develop the data necessary for the design of a HYFLEX pilot plant with which to confirm and optimize future commercial unit designs. Preliminary designs of a HYFLEX pilot plant to process 100 tons of coal per day would be undertaken and procurement of major long delivery equipment items initiated. Operation of the pilot plant will be targeted for 1982, and commercial demonstration might be undertaken by as early as 1985. Further, should our experience prove as favorable as we anticipate, HYFLEX could become a very attractive candidate for addition to our national synthetic fuels production capability, to be established by the Energy Security Corporation, in the latter half of this decade.

FUEL CELLS

IGT continues its efforts in the development of second-generation fuel cell technology toward applications both for cogeneration, and as integrated gasifier-fuel cell power plants.

The gas-fueled, molten carbonate fuel cell is a very attractive power system for industrial cogeneration because, in addition to its superior efficiency of operation, it produces by-product heat at a fairly constant rate which can be used for other processes. A recent IGT study has revealed that significant energy savings and efficient utilization of gas can be achieved with the system. These savings are considerably greater than those achieved by other natural gas-fueled cogeneration systems or by coal- and oil-fueled cogneration. In part, these savings are due to the higher electrical conversion efficiency and the more effective utilization of by-product heat.

Future large-scale fuel cell power plants will require the use of hydrocarbon feeds made from coal which contains sulfur. Varying amounts of sulfur will appear in the fuel cell feed, depending on the fuel conversion and cleanup processes used. Sulfur, even in small amounts, poisons or degrades the performance and useful economic life of the cells. However, both the cost and complexity of the total plant increase in proportion to the amount of sulfur that must be removed. It is, therefore, essential to identify the gas purity requirements of molten carbonate fuel cells. Additionally, since system performance improves with pressure, the relationship of gas cleanup cost and system pressure must be established. The IGT on-going program will: establish the performance and endurance characteristics of molten carbonate fuel cells as a function of sulfur contaminants in both fuel and oxidant feed gases; identify the sulfur tolerance of cell materials; and establish cell performance as a function of gas composition at 5- and 10-atm pressure.

Finally, we are included in a 33-month DOE contract in which we will be investigating the integration of fuel cells with a gasifier. A determination will be made of the type of gasifier and cleanup system, as well as the impact of efficiency, cost and near-term availability. Another of our tasks will be to develop a functional cell technology package capable of meeting cost and cell life qualifications. While developing fuel cell elements and improving electrode characteristics, we will be working to determine better manufacturing techniques for low-cost components and increased life of fuel cells.

In this program, IGT will design, fabricate, and test a 2-kilowatt fuel cell stack. The overall objective of the testing program is to meet the goal of 10,000 hours of operation (~1/4 full life time). After evaluating the effect of gasifier products on a cell, we will plan a facility for the testing of full-scale stack (500 kilowatt) operating in conjunction with a coal gasifier. This planning includes establishing a location, equipment needs, conceptual design and costing for a test to be carried out by DOE at a later date.

In another application, we expect to conduct a program for operating and evaluating a phosphoric-acid fuel cell power plant using digester gas produced by anaerobic digestion of organic sewage sludge. The use of digester gas-fueled phosphoric-acid fuel cells is another attractive cogeneration application which may permit energy conservation and cost savings at an operating sanitary district, and offers environmental benefits. As a result, we expect that the proposed demonstration plant will: demonstrate the first example of an efficient, environmentally acceptable and cost-effective method of digester gas utilization; establish the fuel cell as a viable, economically attractive technology for cogeneration to assist in fuel cell commercialization; demonstrate energy conservation potential; and refine design and economic parameters.

This program is compatible with the national goal of increasing energy conservation and decreasing our dependence on foreign oil. It will result in substantial savings of dollars and energy for a metropolitan sanitary district. The program will help stimulate a significant national (~200 MW) and foreign market for fuel cells and will provide a trained cadre experienced in the design, construction, and operation of an advanced energy utilization facility.

Clearly IGT, with a long history of fuel cell research dating from 1959, and with its work in coal gasification and gas cleanup systems, is uniquely available to optimize coal conversion to electric power. We are actively seeking an opportunity to integrate fuel cells with gas produced from coal to demonstrate the commercial feasibility of this method of electricity generation.

SOLAR THERMAL ENERGY

The Domestic Policy Review suggested a solar energy contribution of up to 20 quads of energy to the annual U.S. energy needs by the year 2000. Of these 20 quads, 3 quads could be provided by solar thermal energy — the concentration of the sun's rays to provide high quality heat energy. Within this solar thermal projection, 2.6 quads might be used as industrial process heat and/or for fuels and chemicals production, and 0.4 quads could be applied to the generation of electricity.

Although past emphasis by DOE in solar thermal R&D has stressed hardware design and solar generation of electricity, IGT has directed its efforts more to the use of solar thermal energy to produce — thermochemically — fuels and chemicals such as hydrogen, alcohol, and ammonia. As a result, we have analyzed systematically which high-volume, energy-intensive chemicals might best be produced by solar thermal energy, and we have just completed a computer model to be used to assess the cost of solar fuels and chemicals production.

In terms of technical accomplishments, IGT recently produced experimental quantities of calcium carbide, from lime and coke, in a solar furnace. Conventional calcium carbide production is a highly energy-intensive process, using electric furnaces. Calcium carbide when reacted with water produces acetylene, a gaseous fuel or feedstock for the production of other chemicals. While much experimental work still needs to be done to better characterize and perfect the process and to determine its economic prospects, the significance of this achievement lies in the demonstration of the production of inexhaustible solar energy. This achievement makes it tempting to contemplate a process utilizing the abundant limestone, coal, and sunlight of Western states to produce a chemical that can act as a feed material for the production of other industrial chemicals or as a means to transport and store solar energy for use at another time and/or location.

Later this year, we plan to utilize a solar furnace at White Sands, New Mexico, to demonstrate the high temperature step of a new IGT Process for producing hydrogen thermochemically. This process involves a reaction of cadmium metal with water to form hydrogen, followed by a high-temperature solar step that converts the reacted cadmium back to cadmium metal in a cyclic process. Thus, ordinary water is converted into an excellent fuel through the application of solar energy.

We also observe that solar thermal energy can be used effectively to produce various alcohol fuels, as well as other high-volume chemicals. Methanol and ammonia are currently produced from natural gas by catalytic high temperature processes. Our studies have shown that these same processes would be logical candidates for adaptation of solar thermal energy. Further, we believe that the net energy efficiency of processing fermentation alcohol for fuel use can be improved with a solar still to replace fossil-fired distillation units. The promise of the contribution of solar energy to produce fuels and chemicals, with the consequence of offsetting the depletion of fossil fuels that are required for other applications, should be investigated aggressively.

We plan to continue our work in these and other applications of solar thermal energy because we believe that they offer an opportunity to conserve the country's fossil fuel resources. However, we feel that the DOE solar budget, which stresses solar-thermal generation of electricity, should be readjusted to reflect the projections of the Domestic Policy Review and place greater emphasis on solar-thermal production of fuels and chemicals.

I appreciate very much the opportunity to present our viewpoints to the subcommittee, and will be happy to answer any questions you may have concerning this testimony. Thank you.

HYGAS® FACT SHEET

The most advanced, new process available to produce SNG from any U.S. coal is the HYGAS Process. HYGAS was developed at IGT in a continuing program that began with associated basic research in 1944, and now has been proven with more than ten thousand hours of operating experience at the HYGAS pilot plant in Chicago, Illinois. As of October, 1979, the plant had produced gas equivalent to about 267 billion Btu, which in turn is equivalent to about 44,500 barrels of oil.

During the past eight years, under the sponsorship of DOE and the Gas Research Institute (GRI), which assumed the former sponsorship of the American Gas Association (A.G.A.), the pilot plant has been utilized to convert Eastern caking high-sulfur-content Illinois No. 6 bituminous coal, as well as Western lignite and subbituminous coals, to SNG. More than 22,700 tons of U.S. coals have been processed at the HYGAS plant; these operations have proven the feasibility of the HYGAS Process for conversion of both lignite from Western U.S. and high-sulfur caking bituminous coal from the Eastern U.S. to SNG. IGT experience and the broad HYGAS data base have been utilized by Procon Incorporated, under DOE sponsorship, in the non-site specific design of a coal-to-SNG demonstration facility for the conversion of Eastern or Western coals to pipeline gas.

Various studies have been made in recent years to compare economics of the emerging coal-to-SNG processes. Typical results of such studies favor the HYGAS Process overall contenders for commercialization. Based on recent studies by Procon, Inc., the price of SNG from the HYGAS Process, assuming utility financing guidelines, would be $3.78 per million Btu with eastern coal feedstock at $1.00 per million Btu (based on mid-1978 dollars).

The conclusion strongly indicated is that the second-generation HYGAS technology offers substantial technology and cost advantages over first-generation technology, and that there is no incentive to wait for the so-called "third-generation" technology. HYGAS is the only process in pilot plant status that has successfully operated for the past three years on highly-caking high sulfur-content Eastern bituminous coals. During two 12-month periods of the past 3 years, HYGAS has processed more than 8000 tons of Illinois bituminous coal, realizing many tests for long duration in which the entire plant was operated in a fully integrated mode. In this period, the HYGAS pilot plant has explored the parameters for a demonstration plant gasifier of commercial scale.

HYFLEX™ FACT SHEET

Pyrolysis of coal in hydrogen at moderate pressure yields products that include fuel oil, gasoline, chemicals, petrochemical feedstocks and gas. Although IGT's interest in this concept dates back many years, the principal work now directed toward riser cracking demonstration was begun in 1976 on an IGT contract with the Energy Research and Development Administration, and continues today under Department of Energy sponsorship. By integrating the riser cracking reactor into an overall coal conversion process, IGT is developing the HYFLEX™ process to provide needed liquid and gaseous fuels and chemicals to meet future requirements.

IGT'S PROGRAM

In the experimental program at IGT, coal is suspended in hydrogen at ambient temperature and the coal-hydrogen mixture is passed through the rising flow of a reactor in which the hydrogen and coal are heated cocurrently to convert about fifty percent of the feed carbon to gases and liquids. This leaves sufficient carbon to supply process hydrogen and to fuel the overall plant.

Process advantages include a simple reactor, high throughput, avoidance of difficult liquids-solids separations, and operation without a catalyst. The pyrolysis plant is of relatively simple design, and produces several high-value products simultaneously. For a given throughput, therefore, the pyrolysis plant should be less capital intensive and have more favorable economics than plants of similar capacity that are based upon existing technology.

CURRENT OBJECTIVES

Work at IGT has moved through the laboratory and bench-scales of testing and will continue in a Process Development Unit (PDU) constructed early in 1979. Objectives of the PDU work include confirming the emerging reactor design concept and obtaining more advanced data for scaling up to demonstration and commercial design. The work to date at IGT has involved feeding principally North Dakota lignite, and processing at reaction temperatures ranging from 1400° to 1500°F, and pressures from 500 to 2000 psig. In addition to the volatile substances released in the process, the process utilizes the char. A commercial concept would incorporate a fluidized-bed gasifier to produce hydrogen for the process, utilizing by-product char (from the riser-reactor), with steam and oxygen, as its feedstock.

In a gasoline and fuels mode, daily production in such a plant, feeding 16,000 tons daily of lignite, would include 805 tons of ethane, 25 tons of propane, 4800 barrels of gasoline, 3900 barrels of fuel oil, and 2500 tons of methane. Preliminary estimates of the production costs of these products with utility financing are \$3.70 per thousand cubic feet for methane, 85¢ per gallon for gasoline blends, and 65¢ per gallon for light fuel oils. Cost of a commercial plant might range from \$600 to \$800 million.

HYTORT™ FACT SHEET

Through the sponsorship of the Gas Research Institute (GRI), the American Gas Association (A.G.A.), and more recently with Department of Energy support, researchers at the Institute of Gas Technology (IGT) have developed the HYTORT Process which provides means for the efficient conversion of all types of oil shales to SNG and/or synthetic crude oil. The HYTORT Process can produce yields up to 250% of Fischer Assay with eastern oil shales.

Until recently, many shales were considered unsatisfactory feedstocks because of their relatively low oil yields in the Fischer Assay test and in conventional thermal retorting. In many instances, most notably in the case of Devonian shales of the eastern United States, Fischer Assay oil yields, per unit weight percent of organic carbon content, have been less than half of those obtained from the more familiar but less abundant shales of the Green River area of Colorado, Utah, and Wyoming. This strongly suggests that yield differences are related to the chemistry of the specific kerogen being retorted, and in particular to its hydrogen content. IGT work has shown that elemental hydrogen reacts with kerogen to enhance the yield of oil and hydrocarbon gases. This work led to the development of the HYTORT Process concept, as described below.

In 1959, research on the direct hydrogenolysis of western (Colorado) oil shale was begun at IGT under sponsorship of the A.G.A. on behalf of the gas industry. In early work, which was directed primarily toward the production of SNG, process feasibility was demonstrated using cocurrent gas-shale contacting with rapid shale heatup. Process economics were favorable. However, shale organic carbon conversions were generally only about eighty percent, with about 65% conversion to gas and 15% conversion to light aromatics — principally benzene.

In 1972, a new study was begun under A.G.A. sponsorship to test an improved process concept, termed HYTORT, suitable for production of SNG or syncrude. Laboratory thermobalance tests showed that, by slow heating of Colorado shale in hydrogen, more than 95% of the organic carbon could be converted to useful products. By contrast, conventional retorting processes only recover 75% to 80% of the organic matter as useful products. These results were confirmed in bench-scale tests using a 4-inch inside-diameter reactor with shale feed rates of about 100 lb/hr. By varying process conditions, it was possible to vary the gas:liquid product ratio over a wide range.

Tests were also conducted with eastern Devonian shales in both the thermobalance and the 4-inch bench-scale unit. Organic carbon recoveries as high as ninety percent were achieved in the thermobalance tests and as high as 85% in the bench-scale tests. This indicated that the HYTORT Process is particularly suitable for eastern shales because conventional retorting can convert only about 35% of the organic carbon in such shales to useful products.

In July, 1976, a 1 ton/hr process development unit (PDU) was put into operation to prove heat-balance operation on a large scale. Results from this unit on both Colorado and eastern Devonian shales have agreed satisfactorily with smaller-scale test results.

The HYTORT Process requires that large tonnages of solid material be continuously fed and discharged from a pressure vessel. In an effort to improve upon conventional techniques (dry, Lurgi-type lockhoppers and pumped slurry feeders), IGT is developing a liquid-sealed lockhopper which requires only a fraction of the power needed for dry lockhoppers and can cycle in a fraction of the time. Tests on this system at the 1 ton/hr scale have been very successful. Per unit of hydrocarbon product, the liquid seal lockhopper costs are about sixty percent of conventional gas pressurized lockhoppers.

An extensive survey of Devonian shale resources has been conducted, involving more than 350 samples from over 100 locations in the eastern United States, to determine the extent of the nation's resources of Devonian shale. IGT estimates that 423 billion barrels of oil could be recovered by HYTORT processing of surface-mineable Devonian shales in the eastern region of the United States.

Economics of the HYTORT Process are attractive. When designed for commercial shale oil production, the price of shale oil is about $22 per barrel (1980 dollars). However, because of the hydrogen treatment, the HYTORT product oil is a light, high quality oil which will yield about eighty percent material in the number two distillate and jet fuel boiling range, or lighter. Therefore, the cost of jet fuel is projected to be about $24 per barrel from this shale oil, equal to or less than the cost of jet fuel from imported crude at today's prices. The hydrogen required for the process is generated within the integrated plant, and the hydrogen cost is included in the above prices. All oil shale processes require hydrogen to produce upgraded synthetic oil; the HYTORT Process shifts some of the hydrogen required in upgrading of raw shale oil to the retorting step to combine upgrading with enhanced kerogen recovery.

U-GAS® FACT SHEET

The U-GAS Process is being developed by the Institute of Gas Technology with DOE funding to produce a clean, environmentally acceptable medium-Btu gas from coal. The process which is a single-stage fluidized-bed gasifier has the following characteristics: simple design and reliable operation, high conversion of feed-coal to gas, capability to gasify all ranks of coal, ability to accept fines in coal feed, ability to produce gas that is free of tar and oils, and capable of maintaining high inventory of coal in the gasifier for safer operation.

Gasifying coal in a fluidized bed has several advantages but has one major drawback. Advantages of fluidized bed are highly effective gas solids contacting, uniform temperature, fast reaction rate, and ease of solid handling. However, the fluidized bed is not capable of discharging low carbon content ash from the bed. This results from the necessity to maintain a relatively high carbon content in the bed to maintain reducing conditions and stable non-slagging operation. To overcome this disadvantage, the U-GAS Process uses an ash agglomeration technique. A continuous and selective discharge of low-carbon-content ash from the bed under non-slagging conditions is obtained. At the same time, the concentration of carbon in the fluidized bed is high enough to maintain reducing conditions and ensure safe operation. The technique enables the gasifier to achieve carbon-to-gas conversion efficiencies comparable to those of the slagging-type of fixed-bed and entrained-type of reactors.

A large potential market for medium-Btu gas exists. With proper incentives the market penetration for medium-Btu gas by 2000 is 1.0 to 4.4 quads. Medium-Btu gas from coal has wider application than just as an industrial fuel. It can be used as a chemical feedstock to produce hydrogen, ammonia and methanol. Another potential application is as fuel for electric power generation through fuel cells and combined-cycles. Also, medium-Btu gas is an essential step in all processes to convert coal to synthetic liquid fuel and gasoline. Use of medium-Btu gas from coal rather than direct combustion of coal could be a major factor in reducing air pollution, especially in large urban areas.

During the past year, we have successfully completed operation of the Memphis Light, Gas & Water fuel gas demonstration plant. The plant will provide medium-Btu gas to industrial customers served by the Memphis Light, Gas & Water Division in Shelby County, Tennessee. Foster Wheeler Energy Corporation of Livingston, New Jersey will be the architect-engineer and construction manager. Delta Refining Company in Memphis, Tennessee is an oil refining company that will provide operations and safety experience and, also, will be a customer of the plant.

The gas cost from a U-GAS commercial plant is estimated to be about \$3.70 per million Btu based on 1979 dollars, using an eastern bituminous coal price of \$26.00 per ton.

PEATGAS™ FACT SHEET

U.S. peat resources are estimated to total about 1400 quads (10^{15} Btu), equivalent to over 200 billion barrels of crude oil. Although peat is found in most states, the largest resources are located in parts of Alaska, Minnesota, Michigan, Florida, Wisconsin, Louisiana, Maine and North Carolina. Many of these states have no other significant resources of fossil fuels; this enhances the importance of peat development in those areas. Peat is associated with adequate water supplies for all types of fossil fuel utilization processes, unlike coal and oil shale resources in some areas.

Our work, originally sponsored by the Minnesota Gas Company and then jointly with DOE, has shown that this very young coal is converted to gas and liquids more rapidly than any other coal. The major part of the liquid fraction is distillate fuel. The mild conditions of the PEATGAS Process simplify reactor design to produce methane and synthesis gas for conversion to SNG. All these factors contribute to attractive process economics.

Gasification tests with peats from Minnesota, North Carolina and Maine have been completed in laboratory-scale as well as in PDU-scale equipment. The tests in the PDU-scale equipment, which represent a scale-up of 250 times the laboratory-scale equipment, confirm the results obtained in the laboratory-scale equipment. The PEATGAS Process for converting peat to SNG is thus ready for the next logical step in its development — large-scale pilot-plant testing.

A mathematical model that describes the kinetics of peat gasification has been developed for the PEATGAS Process. Complete process designs have been prepared for plants producing 250 X 10^9 Btu/day of SNG from Minnesota and North Carolina peats (containing fifty percent moisture content). The plant thermal efficiency of this process is estimated to be about 67%. The price of SNG from a large integrated PEATGAS plant using Minnesota peat is estimated at $3.06 (adjusted to early 1980) per million Btu using peat at fifty percent moisture costing $0.75 per million Btu.

Large-scale peat development presents an unprecedented opportunity to transform an area of unused land into a productive wildlife refuge or agricultural area, while recovering the energy in the peat as clean-burning SNG. An analysis of the environmental impact of such an operation, recently prepared by IGT and Williams Brothers Engineering Co., has helped to demonstrate that these goals can be achieved. This work considered possible impacts of peat harvesting and conversion on air, water and land. Special emphasis was placed on the situation in Northern Minnesota.

An analysis of the design of a peat gasification plant on the IGT PEATGAS Process shows that air pollution control techniques developed for coal gasification plants can limit pollutant emissions to within New Source Performance Standards. The harvesting technique, which would be used, leaves open a wide variety of land reclamation options, ranging from agricultural development, forestry, and recreational lakes to diverse habitat wildlife refuges and self-sustaining energy farms. Reclamation of harvested peatlands for agricultural purposes has been practiced successfully in Europe for centuries. The wildlife refuge option is particularly intriguing because it would actually increase species diversity, providing a vastly improved waterfowl sanctuary while retaining, in some areas, the distinctive character of the original peatlands.

Senator **Matsunaga**. Thank you very much, Dr. Schora.

When you say "use of the gas," is that in HYFLEX process?

Dr. **Schora**. Yes, sir.

Senator **Matsunaga**. How would you go about that?

Dr. **Schora**. The approach that we have been looking at is a rapid contacting of the gas dried with hydrogen. Under such conditions, it could form a large percentage of oil products, liquid hydrocarbon in alcohol products. The fuel would be produced from the waste char from the gas or in Hawaii we are looking also at the conceivable use of excess electrothermal power from geothermal production and shipping the liquid products to the islands as a motor fuel.

Senator **Matsunaga**. I am glad to hear that because, as you probably know, the sugar industry out there is proposing to build a $40 million ethanol plant for gasohol, to produce ethanol from sugarcane. With the price of fuel going as high as it is now, they are beginning to produce it economically.

Dr. Rosenberg, in your testimony you called upon the committee to support the administration's budget request of $20 million for in situ coal gasification for fiscal year 1981. However, you know that the amended request for next year calls for a $5 million reduction in this program, and there is no mention of the funds to come from the windfall profits Tax Act.

There might be $10 million, but we are not sure. Now, this would leave only $5.3 million in the in situ coal gasification program for next year. How would this cut affect the program?

Dr. **Rosenberg**. Mr. Chairman, thank you for correcting my words. I should have indicated we were supportive of the administration's original budget request and not the revised one, the $5 million that you point out. Our staff are currently meeting with the Department of Energy people and with the National Laboratories to determine just what impact that will have on the overall program.

It is our view at this point on a preliminary basis that that will provide sufficient funds for a barely adequate holding action, but not really advance the technology as appropriately as it should be, sir, so we would still urge the full funding of that program at, at least, the $10 million level, preferably the $20 million level, but the $5 million will barely be adequate.

Senator **Matsunaga**. I am strong in the belief, as you probably heard me say earlier when other witnesses appeared before the committee, that in situ coal gasification promises to be one of the most immediate and abundant sources of energy to replace imported crude oil.

What is your belief on this? Assuming that we fully fund it as you recommend, when is the earliest time that you think we can commercialize coal gasification under this process?

Dr. **Rosenberg**. Mr. Chairman, in my view, had you asked me that question 2 years ago, I would have responded to you that this is a very difficult technology because we don't understand really what is going on underground and we don't know how to control it.

The rate of progress in these developments has been most gratifying to us and we are considerably more optimisitc now than we would have been had you asked 2 years previously.

On that basis, if the development continues at the pace that the National Laboratories, in particular, have been doing, I would think that we could see pilot scale plans moving into demonstration and development within the next 10 year time frame.

If, however, we run into technological uncertainties, that could stretch up.

Now we are being cautiously optimistic that things are looking very favorable.

Senator **Matsunaga**. Dr. Schora, in your testimony you call for the Department of Energy to select a winner from the two competitors for the high-Btu coal gasification demonstration plant. Then the loser would go into competition with the high gas project for selection to build a second plant.

Is the design work for the high gas project as far advanced as the work of the two competitors for the high-Btu coal gasification plant?

Dr. **Schora**. To my knowledge, the design effort from actually being site specific is somewhat behind out of the two competitors. However, based on the work done by Pro-con and our analysis of the critical path, that is not on the critical path.

In other words, from the standpoint of completing either one of the two existing competitors or high gas from an initial starting point of, say, today, either one of the two processes would have no advantage over high gas at this point.

Further, the data base for the high gas process is considerably more extensive than it is for the other two processes.

Senator **Matsunaga**. We may have other questions, but I have to go vote again. If we have any further questions, we will submit them to you in writing. We would appreciate your responding in writing.

Dr. **Rosenberg**. I would be happy to. Thank you very much, Mr. Chairman.

Dr. **Schora**. Thank you, sir.

Senator **Matsunaga**. I will be right back, Dr. Hunter and Mr. Fri. The committee stands in recess subject to the call of the Chair.

[Recess.]

Senator **Matsunaga**. Dr. Hunter.

STATEMENT OF DR. OSCAR B. HUNTER, JR., M.D., DIRECTOR, HUNTER MEMORIAL LABORATORY, WASHINGTON, D.C., REPRESENTING THE SOCIETY OF NUCLEAR MEDICINE, NEW YORK, N.Y., ACCOMPANIED BY HENRY ERNSTALL, EXECUTIVE DIRECTOR OF THE SOCIETY OF NUCLEAR MEDICINE

Dr. **Hunter**. Yes, sir. Mr. Chairman, I have with me Henry Ernstall, the executive director of the Society of Nuclear Medicine. I am a trustee of the Society of Nuclear Medicine.

Senator **Matsunaga**. You may proceed.

Dr. **Hunter**. I will be short because we have a statement which we have submitted to you. We would be pleased if you would put this in the record.

Senator **Matsunaga**. The statement will appear in the record in full.

Dr. **Hunter**. Let me summarize our position here. We are here to support the DOE's fiscal year 1981 appropriation recommendations and we would urge the committee to support this, too.

Fundamentally, we have two areas that we are concerned with and one of them is the research area and two is the disposal of low-energy waste. These two budget items we feel are worthy of the committee's consideration for these reasons.

Basically in the research area, the contribution of nuclear medicine to improved studies, rapidity of diagnostic procedures, improvement of therapy, and elimination of expensive hospitalization is a contribution nuclear medicine is making to the overall health needs of our people.

Basically, we do two types of things—imaging, identifying cancer or other pathological lesions in the body by use of radioactive isotopes, making images of those and in vitro studies that can identify a small quantity of substance in the body such as hormones, cortizone, or the like, any of these hormones that are very difficult to identify otherwise.

We are able by use of these methods to identify one-millionth of a microgram of a substance. In other words, we are dealing with molecular chemistry. There are many other areas that should be investigated and that is why we would support the concept that research be favored by this appropriation.

Now, I could enumerate many cases and citations of what we do, but I think, Mr. Chairman, rather than take your time to do that, that our statement does enumerate these and these are commonly used in our hospitals and laboratories in all of the communities of the country at the present time.

The big problem that we have is that the procedures of the isotopes have the difficulty of disposing of the material that are waste products from the preparation and finally the getting rid of or disposing of the low-level activities of the materials that are going into the production of the isotope.

And this needs to be taken care of primarily because if they are not taken care of, then our supply of isotopes is not going to be readily available. That not being readily available, our needs for the health of our people is not properly cared for.

So that the appropriation for approximately $20 million for the research and $4 million for study of the low-level waste disposal are the things which we would support and hope your committee would support.

Parenthetically, a study needs to be done to unify and boil down to practicality the overall regulations which do govern disposal of radioactive waste. We have the Nuclear Regulatory Commission, the Environmental Protection Agency, the Department of Transportation, and they need to be coordinated so that a safe disposal can be had with a mininum of the problems having to do with them and eliminating the difficulties that are presently being experienced.

Mr. Chairman, that is all that I have to identify, other than the statement that we have submitted. We would be glad to answer any questions that you might have in this situation.

[The prepared statement of Dr. Hunter follows:]

THE SOCIETY OF NUCLEAR MEDICINE
475 PARK AVENUE SOUTH, NEW YORK, N.Y. 10016 · TEL. 212 889-0717

STATEMENT
OF THE
SOCIETY OF NUCLEAR MEDICINE
CONCERNING
FISCAL YEAR 1981 AUTHORIZATIONS
FOR THE
DEPARTMENT OF ENERGY
OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH
HUMAN HEALTH STUDIES PROGRAM
IN
NUCLEAR MEDICINE RESEARCH

RECOMMENDATIONS
DEPARTMENT OF ENERGY
OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH
HUMAN HEALTH STUDIES PROGRAM
IN
NUCLEAR MEDICINE RESEARCH

I. That the proposed Fiscal Year 1981 budget for Nuclear Medicine Research in the Human Health Studies Program of the Office of Health and Environmental Research of the Department of Energy be authorized.

II. That research efforts be emphasized in

  A. Expanded radioisotope production

  B. Radiopharmaceutical research

  C. Nuclear medicine instrumentation

III. That the proposed Fiscal Year 1981 budget that encompasses low-level waste disposal be authorized.

STATEMENT OF THE SOCIETY OF NUCLEAR MEDICINE
CONCERNING
FISCAL YEAR 1981 AUTHORIZATIONS
FOR THE
DEPARTMENT OF ENERGY
OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH
HUMAN HEALTH STUDIES PROGRAM
IN
NUCLEAR MEDICINE RESEARCH

The Society of Nuclear Medicine is pleased to have the opportunity to present its comments and views on proposed Fiscal Year 1981 authorizations concerning nuclear medicine research activities within the Department of Energy. The Society recognizes that the constraints on the 1981 budget, as imposed by the Presidential Budget message, make it critical to justify why and how more research should be supported. It can be shown that, in this discipline, a very rapid translation of basic research into clinical realities occurs, and how more benefits are returned to the American public, per dollar invested, than in probably most other fields of health-related research.

SOCIETY OF NUCLEAR MEDICINE

The Society of Nuclear Medicine, founded in 1954, is the largest all-encompassing umbrella-like organization dedicated to all aspects of the field of nuclear medicine in the United States, especially in health care and in research. Among its 9600 members are physicians, physicists, chemists, radiopharmacists, nuclear medicine technologists and others with career interests in the diagnostic and therapeutic use of radioactive materials for medical application.

WHAT IS NUCLEAR MEDICINE TODAY

Nuclear medicine is the use of radioactive materials in the diagnosis (and, in some limited instances, in the therapy) of disease in humans. The symptoms patients present often could be related to two or more different causes, each requiring different types of treatment. Good diagnostic procedures are therefore essential, as they allow us to direct the management of the patient in an appropriate manner, and avoid costly (both in dollars and in physical pain and mental anguish) delays in selecting the correct treatment. Nuclear medicine studies provide such techniques in a unique manner.

These studies or examinations are of two basic types. In one type, the in vivo study, a small amount of a radioactive drug is administered to the patient, usually by injection, and the course of the drug through the body is followed and visualized with very sophisticated instrumentation. Permanent images of this biodistribution are recorded on films. In some cases, the data derived from the examination are subjected to computer analysis and the image is then reconstructed by the computer, thus further improving the overall resolution and diagnostic accuracy of the study. Most major organ and tissue systems of the body can be examined in this fashion, including the brain and central nervous system, lungs, liver, kidneys, bone, thyroid, pancreas, and the cardiovascular system. In many of these nuclear medicine diagnostic studies, the absence of any disease process or pathology is documented, which in itself is valuable information for the attending physician and can be a matter of great psychological relief to the patient as well. In those cases where a problem is found, the study provides exceedingly important information regarding the location and extent of the disease process. In some situations, the information derived from the nuclear medicine study can be life saving. In others, at the very least, it assists the physician responsible for the care of the patient in providing the most efficient and best treatment possible under individualized circumstances. It should be noted that nuclear medicine in vivo diagnostic procedures are non-invasive, safe and essentially painless for the patient; the only sensation the patient feels is that occasioned by the needle stick when the drug is administered.

It is estimated that more than 60 million nuclear medicine procedures are performed each year in hospitals and clinics in the U.S. When one considers that, on the average, a nuclear medicine procedure is performed on one out of every two people admitted to hospitals in the U.S., the impact of this medical specialty on health care delivery becomes apparent. Approximately 37 million people are admitted to hospitals in this country each year. In addition, large numbers of nuclear medicine studies are ordered for out-patients, who are not admitted to hospitals.

HOW EFFECTIVE ARE NUCLEAR MEDICINE PROCEDURES?

What benefits have been realized from the development and the utilization of nuclear medicine procedures, and why is more research likely to yield even further benefits? The Society believes that nuclear medicine procedures, by contributing effectively to improved patient diagnosis (a) reduces total treatment expense, hospital time and patient suffering by directing therapy more rapidly towards the appropriate causes of the disease, and (b) provides, in many areas, greater information on the patient's problems than any other currently available modality. Because in essence nuclear medicine procedures involve the study of dynamic body functions, they tell us what the body does (or does not do), as opposed to static radiologic procedures, which show what is (or is not) present.

In addition, nuclear medicine procedures are a unique area where basic research in the chemical, biological, physical and related sciences, clinical research and patient care merge and work effectively together, allowing a rapid transfer of basic science findings in the research laboratory into clinical practice. A number of specific examples may document these statements.

Example - Nuclear Cardiology Imaging

One of the most dramatic examples of the rapid transfer of high technology nuclear medicine development into a major health problem area is in the study of coronary heart disease. Heart attacks kill approximately 700,000 people annually and are the leading cause of death in the United States. Almost 300,000 individuals suffer their first heart attack without prior knowledge of having coronary artery disease. Great strides have been made in attempting to deal with this serious health problem. Nuclear diagnostic techniques that have recently been developed and applied in just the past three years have already shown to be significantly more sensitive in identifying individuals with diseased coronary arteries than previously used methods, such as electrocardiographic stress testing.

These important advances have been the result of research programs directed both towards developing improved instrumentation and identifying better radioactive trace substances necessary to study the natural history of the disease and the hemodynamic consequences of coronary artery narrowing on heart function. These newly developed nuclear cardiology diagnostic methods are being applied clinically with increasing frequency in outpatient facilities for screening men and women in certain high risk categories for heart disease, and they are used to assess the extent of damage when heart attacks have occurred. The use of such procedures has resulted in significant savings in hospitalization costs, formally required for more extensive diagnostic tests such as, for example, cardiac catheterization.

Investigators in nuclear medicine working under Department of Energy, Office of Health and Environmental Research, Human Health Studies Program support, have made many of the most significant contributions in this field through their development of advanced detection instrumentation for the use in nuclear medicine to produce and test the necessary radioactive diagnostic agents. Even so, researchers have only begun to explore the full potential of these newer tests to detect latent heart disease and to evaluate the benefits of modern medical and surgical treatment.

We realistically anticipate that, with increased funding for research in this field, improved diagnostic procedures will quickly become available to community practitioners to more effectively deal with this devastating health problem, which affects all citizens either by direct suffering or in terms of reduced national productivity.

Example - Cancer Studies

Another specific example can be gleaned from oncologically related studies. The major emphasis of nuclear medicine in the field of cancer has moved from therapeutic uses of radioactive materials to the early detection and staging of cancers, using novel imaging modalities. We are now witnessing the growing use of nuclear medicine procedures in monitoring the therapy of cancer and in the follow-up of recurrences. Although imaging procedures constitute a valuable adjunct to early diagnosis and staging, without which the practice of modern medical oncology could not be conducted, there are limitations in the size of lesions which can currently be detected, and the results are frequently non-specific. We need to perfect and improve these techniques by obtaining more specific radioactive tracers, by pursuing more sophisticated immunologic and biochemical studies, as well as by developing instruments with better spatial resolution, such as if offered by emission tomographic techniques. The detection in the patient of "tumor markers" using radioimmunoassay techniques has resulted in the detection of primary tumors and of metastases before they have become evident clinically.

Research into improving the sensitivity and specificity of these and other tumor detection assays promises to have a great impact on patient care. Early and accurate diagnosis is one of the crucial factors in allowing the medical oncologist to decide on the desired course of treatment, hence decreasing hospital stay and lengthy trials with what often becomes unresponsive modes of treatment.

In addition, nuclear medicine procedures are a most important means of monitoring therapy in the cancer patient, providing information on progression and/or regression of the tumor, and thereby allowing the clinician to continue or modify his treatment accordingly. Among the most serious problems in cancer chemotherapy are the serious side effects that antineoplastic agents bring about. Here again, such effects can be most efficiently monitored by the use of nuclear medicine procedures. As examples, the effects of chemotherapy in producing inflamatory lesions in lungs; the presence of complicating infections; the cardiotoxic effects of adriamycin may be detected by the use of cardiac wall motion studies and ejection fractions. These techniques are growing in use and are representative of how nuclear medicine methods affect the field of cancer treatment.

Example - Pediatric Nuclear Medicine

A further example of cost effectiveness and how research and development of nuclear medicine techniques has impacted the health care is in the area of pediatric nuclear medicine. A bone scan is a most effective agent in the early differential diagnosis of cellulitis from osteomyelitis, allowing the decision to be made between a short hospitalization for the patient with cellulitis, compared to the several week hospitalization and drug therapy for the patient with osteomyelitis. In addition to the cost effectiveness, this ability to make an early decision also avoids, for children and their families, the trauma of unnecessary hospitalization.

As a final comment on the growing impact of nuclear medicine, the first Nobel Prize in Medicine to be awarded for research in Nuclear Medicine went in 1978 to an American, Dr. Roslynn Yalow. Dr. Yalow, then a researcher at the Veterans Administration, pioneered and developed the field of radioimmunoassay, a method that is unique today in that it can detect readily, accurately and inexpensively most any substance present in biological samples in as little as a fraction of a billionth of a milligram! Over 50 companies exist now in the United States manufacturing radioimmunoassay materials, and these are the procedures of choice in the detection of many disease markers, pollutants and toxic materials in the biological environment.

Many more examples could be given, drawn from research in progress in such crucial fields as mental health, lung disease, renal disease and many others. In essence, these examples all document one definitive fact: nuclear medicine prodedures are a prime example of rapid technology transfer, where research findings are applied to clinical problems in a very short time. These procedures are clinically useful, cost effective and non-invasive.

The Society of Nuclear Medicine would welcome the opportunity to identify research targets and potentials to capitalize on federal research dollars invested. The Society of Nuclear Medicine therefore urges Congress to vigorously continue supporting increased research in this area, commensurate with the magnitude of the problems involved, such as heart disease, cancer, mental health, etc., based on the demonstrated and anticipated benefits that decisions based on the results of nuclear medicine procedures will bring to all citizens.

PROMISING AREAS OF RESEARCH

What are some of the areas for which these new research funds should be used? In addition to further developments and efforts in the areas mentioned above, these funds should be utilized for research in the following areas:

(a) Expanded radioisotope production efforts to develop new nuclides from accelerators and to increase the supply of radionuclides for intramural and extramural research in radiopharmaceutical development and clinical feasibility studies.

(b) Radiopharmaceutical research to enhance our understanding in the areas of pharmacodynamics and pharmacokinetics, to increase the specificity of uptake, to measure the effects on biodistribution caused by varying functional groups on radiopharmaceuticals and by drug interactions, to address problems related to biological effects of environmental pollutants, and to achieve patient dose reductions through development of labeled agents having radionuclides with more desirable decay properties and/or biological half-lives.

(c) Nuclear medicine instrumentation research, specifically in areas of new detector research and emission tomography development.

LOW-LEVEL WASTE DISPOSAL

The Department of Energy is also involved in other activities that can have a substantial impact upon the profession's ability to provide nuclear medicine services to patients across the country. Included in the budget is about $4 million for low-level waste technology. Nuclear medicine is dependent upon a continuing supply of radiopharmaceuticals. Our suppliers must be able to dispose of their low-level radioactive wastes to continue in operation.

Recent events have shown the fragility of the current system. At one point, only one site was available nationally for the disposal of low-level wastes.

There are many alternative solutions to this problem currently under development both by the federal government and by the states. The Society of Nuclear Medicine is working with all interested individividual groups in the search for a solution. The Society policy statement is attached.

The Department of Energy is intimately involved in this process. The Society of Nuclear Medicine urges authorization at the level proposed in the original budget.

Senator **Matsunaga**. Thank you very much. I appreciate your brevity.

Inasmuch as I am already late for an appointment—however, there is one question.

Are you involved in use of nuclear energy for medicinal purposes.

Dr. **Hunter**. We are involved with the use of the radioactive isotopes, the product of reactors and accelerators. We get the final product, something like I-131 or technetium 99. These are the most common isotopes we use in the human body to identify the presence or absence of disease.

Senator **Matsunaga**. But not the cure of illnesses caused by overexposure?

Dr. **Hunter**. Not for treatment of overexposure, but we are involved with the use of cobalt, which is, again, an emitter and does the same. thing that X-ray does in therapy.

We have in many of our larger hospitals cobalt emission machines which do give cobalt gamma radiation to tumors and do the same thing that X-ray will do. But we are not primarily ourselves involved with reactors, only in the sense that the reactors are the source of our isotopes.

Senator **Matsunaga**. Thank you very much, Dr. Hunter. We appreciate your appearance before this committee.

Our final witness today is Mr. Robert W. Fri, executive director, Electric Utilities Fuel Cell Users Group.

STATEMENT OF ROBERT W. FRI, EXECUTIVE DIRECTOR, ELECTRIC UTILITIES FUEL CELL USERS GROUP, WASHINGTON, D.C.

Mr. **Fri**. I am Robert W. Fri, president of Energy Transition Corp., and acting executive director of the Fuel Cell Users Group recently established by the electric utility industry. I am accompanied by representatives of the American Public Power Association, the Edison Electric Institute, and the National Rural Electric Cooperative Association. These organizations, and 31 of their member companies, are charter members of the Users Group.

I have a brief statement which I will try to abbreviate, recognizing——

Senator MATSUNAGA. I would appreciate it very much, and your statement will appear in the record as though delivered in full.

Mr. FRI. Our chief purpose in appearing before you today is to inform you of the existence of the Fuel Cell Users Group and the role we believe it can play in bringing the phosphoric acid fuel cell into commercial use by the electric utility industry.

As you doubtless know, both individual electric utility companies and the Electric Power Research Institute have invested considerable time and money in the development of phosphoric acid fuel cells. This investment and continuing interest has contributed importantly to bringing the fuel cell to a point that today we can seriously contemplate its commercial application.

I believe the industry generally, and a number of its member companies, continue to be committed to active expioration of the fuel cell's commercial potential.

As the program began its passage to the commercialization phase, however, two facts become clear. First, the industry was the ultimate beneficiary of the success or failure of the fuel cell. As such, it bears a responsibility both to itself and to other program participants to express forcefully the industry's needs in the design of the commercial fuel cell and in the formulation of a commercialization program.

Second, it became clear that no institution existed to perform this role. No single utility could do so. EPRI is not chartered to conduct commercial activities and, despite its leadership in development of the technology, could not go deeply into commercialization.

Thus, a need existed to form a new organization, the Fuel Cell Users Group. The Users Group charter has been approved by 37 charter members. I am submitting a copy of the charter for the record, but it may be useful here to read the statement of purpose of the group as contained in the charter to underscore the active role that the group intends to play.

> The purpose of the Group is:
>
> To encourage the development of fuel cells by interactions with the utility industry, Government agencies, developers and others.
>
> To coordinate, cooperate and exchange information within the utility industry and with other public or private organizations, concerned with the development and utilization of fuel cells.
>
> To provide a coordinated body through which members of the Group may cooperatively identify, sponsor, support, and participate in research, development, engineering demonstration, and utilization of fuel cell energy systems.
>
> To provide a body of potential users to assist the fuel cell developers in defining (a) fuel cell system requirements and specifications for electric utility application; and (b) the market potential for fuel cell systems having said specifications.

Two words should be said about the composition of the Users Group. It is first of all quite broadly based, encompassing utilities of all sizes.

Thirty-two utilities are charter members, about half being public power and rural electrification systems. The other five members include the associations represented here today, plus the REA and the TVA.

Geographically, the members range from Oregon and California to New Hampshire, and from Minnesota to Mississippi. These are, of course, only the charter members; we expect the list to grow as the group gets underway.

The group is governed by a board composed mainly of chief executive officers of member organizations. There are 15 directors—8 from investor owned utilities, 2 from rural utility systems, 3 from municipal utilities, and 2 from Federal utilities.

I would like to submit for the record a list of both members and directors, since I feel they testify to the diversity and depth of industry support for both the fuel cell and the Users Group.

Although the Fuel Cell Users Group is designed primarily to work on commercialization issues, successful commercialization depends on successful conclusion of the technology development efforts underway since the early 1970's. As you may know, EPRI, DOE, and other participants have agreed on the goals and content of the necessary technology development work. The fiscal year 1981 DOE budget, along with funds already programed by EPRI and others, provides the resources for this work.

The NRECA underscored the important role of DOE in the fuel-cell program when its 11,000 members passed a resolution at its 1980 annual meeting in early March calling on DOE to support a comprehensive fuel-cell program. I would like to submit a copy of this resolution for the record.

Both the APPA in testimony this year, and EPRI in testimony last year, have stressed the need for about $15 million of DOE funding in fiscal year 1981 to implement the agreed electric utility program.

I join with them in urging your approval of funding at this level. Furthermore, in view of widespread interest, particularly among combined electric and gas utilities, in the 40 kilowatt fuel-cell program, I suggest that funding for this effort be restored to at least the fiscal year 1980 level of about $11 million.

Mr. Chairman, we are pleased that the users group is now in operation and available to your committee members and staff to express the views and needs of the marketplace.

[The attachments to Mr. Fri's statement follow:]

ATTACHMENT I

CHARTER
FOR
FUEL CELL USERS GROUP

BACKGROUND

- The electric utility industry has an urgent need for electric supply options that will more efficiently, and with minimal environmental impact, use currently available fuels, while also providing the capability to use future synthetic fuels.
- A modular phosphoric acid fuel cell energy system that offers the utility industry the potential for environmentally acceptable, efficient and low cost power generation is a candidate for commercial development in the near term.
- Electric utility fuel cell development has been in progress since 1972 through programs funded and coordinated by utilities, manufacturers, EPRI and DOE. A 4.8 MW module of this technology will be demonstrated in 1980-1981; and both DOE and EPRI are funding on-going programs to reduce power plant cost, improve endurance, and expand fuel capability.
- EPRI has a strong interest in seeing that the results of its fuel cell research and development activities become available in the market place, but is not chartered to conduct the commercial activities which accomplish that end.
- Further commitments by the developers, users, government and other interested organizations will likely be required to move from the present development status to a fully validated commercial product.

NEED

- A need exists to develop information regarding utility requirements, market potential, and power generation considerations and to exchange that information with other organizations in order that such organizations might better focus their fuel cell-related activities.

12/18/79

- Furthermore, decisions will be required regarding the applications, specifications, requirements and capabilities (fuel flexibility, cogeneration, etc.) of a fuel cell energy system that will be acceptable to the user.

- In addition, there is a need to disseminate fuel cell related information to an expanded segment of the industry in order to obtain a broader base of support.

These needs can be effectively addressed by a "Fuel Cell Users Group" that would provide several functions, including:

- An industry group complementing EPRI's role in moving fuel cell technology from demonstration into utility service

- A spokesman for the industry regarding the fuel cell's applications, benefits, market potential, etc.

- A focal point for expanded utility interest and involvement

- A user interface for the developers

PURPOSE

The purpose of the Group is:

- To encourage the development of fuel cells by interactions with the utility industry, government agencies, developers and others.

- To coordinate, cooperate and exchange information within the utility industry and with other public or private organizations, concerned with the development and utilization of fuel cells.

- To provide a coordinated body through which members of the Group may cooperatively identify, sponsor, support, and participate in research, development, engineering, demonstration, and utilization of fuel cell energy systems.

- To provide a body of potential users to assist the fuel cell developers in defining a) fuel cell system requirements and specifications for electric utility application; and b) the market potential for fuel cell systems having said specifications.

ACTIVITIES

Activities of the Group may include the following:

- Represent users interests in developing the specifications and design of commercially acceptable products, including plant configuration, performance specifications, and requirements for use of synthetic fuels.
- Represent users interests in designing and implementing a program to introduce fuel cells into utility service working especially with government and product developers to:
  - a) Formulate the program
  - b) Estimate fuel cell market penetration and economics
  - c) Evaluate program progress, particularly on environmental, safety, siting, and related issues.
- Coordinate requirements of potential users into an overall schedule for the introduction of commercial units.
- As required, coordinate program funding by the utility industry; the users group shall not be precluded from receiving and disbursing government or private sector funding if that is required by the program.
- Promote a vigorous fuel cell supply industry, including the encouragement of technology licensing and multiple sourcing of components.
- Build industry participation and support for the program through information and assistance activities.
- Promote public awareness of the fuel cell's beneficial characteristics (environmental and energy conservative) through information dissemination activities.

MEMBERSHIP

Membership in the Group is voluntary and is open to all electric utilities. Other organizations may be considered for membership.

Any electric utility shall be eligible to apply for membership in the Group if such electric utility:

- Expresses a willingness to accept and support the objectives of the Group; and
- Shall be willing to provide effective representation to the Group's committee structure. A group of small utilities may wish to select a single representative to participate on their behalf.

ORGANIZATION

A Directorate comprising top management officials of participating utilities shall provide policy guidelines to the Group. The Directorate will consist of 15 members to be elected by the Membership as follows:

2 from federal utilities
3 from municipal utilities
2 from rural utility systems
8 from private investor owned utilities

A Directorate Chairman will be elected (by the Directorate) to serve a two-year term.

The Directorate will appoint a Management Committee from the General Membership as well as a Committee Chairman who shall serve a term of two years. As soon as practical, the Management Committee will elect a Vice-Chairman, and a Secretary.

All elected officers shall serve a term of two years.

As required the Management Committee will appoint Standing Committees (such as the Specification Committee) to address special missions. Generally, such committees will have a limited period of duration and a limited membership. Standing Committees may utilize additional utility personnel or expertise from non-utility organizations.

MEETINGS

Meetings of the Management Committee will be held quarterly. Additional meetings may be held as required to achieve the objectives.

Meetings of the General Membership will be held semiannually.

DURATION

The duration of this Charter is to December 31, 1985 or whenever the General Membership agrees (by simple vote) that electric utility fuel cells are commercially available.

12/18/79

ATTACHMENT II

CHARTER MEMBERS FUEL CELL USERS GROUP

Adams Electric Cooperative
Allegheny Electric Cooperative
American Public Power Association
Arizona Public Service Company
Baltimore Gas & Electric Company
Basin Electric Power Cooperative
Boston Edison Company
Carolina Power & Light Company
Central Illinois Light Company
Consolidated Edison Company of New York
The Dayton Power & Light Company
Easton Utilities Commission
Edison Electric Institute
Green Mountain Power Corporation
Hoosier Energy Division, REC Inc.
Hydro-Quebec
Lee County Electric Cooperative
Lincoln Electric System
City of Martinsville
Massachusetts Municipal Wholesale Electric Company
Memphis Light, Gas and Water
Mississippi Power & Light Company
National Rural Electric Cooperative Association
Niagara Mohawk Power Corporation
Northeast Utilities Service Company
Northern States Power Company
Ohio Edison Company
Philadelphia Electric Company
Portland General Electric Company
Public Service Electric & Gas Company
Rural Electrification Administration
Santa Clara Electric Department
Seminole Electric Cooperative
Southern California Edison Company
Taunton Municipal Lighting Plant
Tennessee Valley Authority
United Power Association

ATTACHMENT III

NOMINATED SLATE OF DIRECTORS, FUEL CELL USERS GROUP

One Year Term *

Mr. Robert W. Feragen
Rural Electrification Administration

Mr. Barry R. Flynn
City of Santa Clara Electric Department

Mr. Donald C. Lutken
Mississippi Power & Light Company

Mr. William McCollam, Jr.
Edison Electric Institute

Mr. Robert I. Smith
Public Service Electric & Gas Company

Two Year Term *

Mr. Richard C. Clancy
Niagara Mohawk Power Corporation

Mr. William H. Corkran, Jr.
Easton Utilities Commission

Mr. William R. Gould
Southern California Edison Company

Mr. William F. Matson
Allegheny Electric Cooperative, Inc.

Mr. Lelan F. Sillin, Jr.
Northeast Utilities Service Company

Three Year Term *

Mr. Richard M. Freeman
Tennessee Valley Authority

Mr. Charles F. Luce
Consolidated Edison Company of New York

Mr. Robert D. Partridge
National Rural Electric Cooperative Association

Mr. Alex Radin
American Public Power Association

Mr. Frank M. Warren
Portland General Electric Company

* Selected by random draw; in the future, 5 members will be elected each year; incumbents will be eligible for reelection.

NRECA ANNUAL MEETING 1980

ATTACHMENT IV

RESOLUTION NO. J-1

FROM: Research and Technological Development Committee
APPROVED BY: Resolutions Committee

SUBJECT: Federal Support for Fuel Cell Commercialization

Rural Electric cooperatives have great interest in the development of fuel cell power plants because of significant advantages not found in conventional generating equipment. These characteristics show promise of economic benefits for the consumer, improved service availability, conservation of fuel resources, and a cleaner environment.

Commercialization of fuel cell power generation is so near, yet so far from being achieved. The phosphoric acid fuel cell has been developed to the point of large-scale demonstration at the power plant level. But the continued commercial development of the fuel cell continues to need major Federal government financial support.

The next step in establishing commercial viability involves broad exposure in the market environment. The risk of proceeding as a strictly private investment has become unacceptably high, due to the economic climate and changing and unpredictable government involvement in utility decisions.

It is both essential and proper that the Federal government assume a significant portion of the financial burden. We urge the Department of Energy, with support from the Congress, to support a comprehensive integrated program with all segments of the utility industry to provide a basis for commercial fuel cell power plant development for electric utility service.

Senator Matsunaga. Mr. Fri, as a former Administrator of ERDA, your views are very much respected here, and your group ought to be appreciative of the fact that you are with them.

Mr. Fri. I am happy there are so many utilities interested in this. I think it represents a real commitment on a very broad base of industrial participation.

Senator Matsunaga. If it will help you in getting a pay raise, you may ask for a transfer.

I would like to ask questions, but I am already late for an appointment in my office. We may submit questions to you in writing, if you do not mind if we feel later that these questions need to be answered for the record; and I would appreciate your responding in writing so that we may include your responses in the record.

Mr. Fri. We would be happy to.

Senator Matsunaga. Much as I would like to sit here and find out a little more about fuel cells, I do have a prior commitment. We were supposed to be finished by 4:30 p.m.

Thank you very much.

Mr. Fri. Thank you, Mr. Chairman.

Senator Matsunaga. The subcommittee stands adjourned, subject to the call of the Chair.

[Whereupon, at 4:40 p.m., the hearing was adjourned, subject to the call of the Chair.]

DEPARTMENT OF ENERGY FISCAL YEARS 1981-82 AUTHORIZATION

(Civilian Applications)

WEDNESDAY, APRIL 23, 1980

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
OF THE COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:10 p.m., in room 6226, Dirksen Office Building, Hon. Frank Church, presiding.

Present: Senator Church.

Also present: Willis Smith, professional staff member.

OPENING STATEMENT OF HON. FRANK CHURCH, A U.S. SENATOR FROM THE STATE OF IDAHO

Senator CHURCH. The subcommittee will come to order.

This afternoon's hearing before the Subcommittee on Energy Research and Development is to examine the programs under the Assistant Secretary for Nuclear Energy.

As chairman of the subcommittee, I view the proposed budget for the Assistant Secretary for Nuclear Energy Programs with considerable concern, not only with regard to the nuclear fission programs, but also with respect to the nuclear management program.

Under the direction of this administration, the nuclear energy programs within the Department of Energy have suffered continual cuts in the budget requests for each successive fiscal year.

With the primary exception of nuclear waste management, all aspects of the fuel cycle and most of the reactor development programs have undergone major traumas in funding due to inconsistent and contradictory policies.

I believe it is useful to characterize the magnitude of the impact of the administration's positions on the nuclear energy programs.

The national uranium resource evaluation program was hyped as a necessary part of our national program to determine precisely what our uranium resources in the United States are.

This year, there is a major curtailment in this program, as it is proposed to the Congress.

The uranium enrichment program has undergone slippages in the date of completion of the Portsmouth add-on enrichment facility, with a further $170 million cut in the budget for this project in the latest budget revisions.

Work on fuel-cycle related activities has been virtually eliminated in each successive year, with many of the activities rescued by congressional action to maintain work on breeder and other advanced reactor fuel cycles.

In 3 short years, the administration has taken an $855 million budget pending before the Congress for fiscal year 1978 for the liquid metal fast breeder reactor program and pared that to a skeleton program of only $310 million in fiscal year 1981, without taking into account the unseen and recorded losses in the program due to inflation.

This budget undercuts the credibility of past assurances that, while we would not commit to a demonstration facility for the liquid metal fast breeder reactor, we would continue to support a strong and aggressive research and development program to insure that we had the requisite competence to do so at some later date.

I believe that this budget submittal clearly repudiates that past statement of general support for breeder technology.

This year's budget has totally eliminated funding for work on gas-cooled reactors—both the high temperature gas reactor and the gas-cooled fast breeder.

If no restoration is made in the activities associated with these programs, we will decimate the ranks of the technical experts associated with these important technologies. And it could well be an irretreivable loss to the Nation.

In the area of nuclear waste management, the administration issued a policy nearly a year after the interagency review group completed its report.

The effect of this policy is to stop work on numerous things in both the civilian and the defense waste programs which could have provided some assurance to the public that a nuclear waste disposal technique exists many years earlier than the currently planned estimates of completion of the first long-term disposal facility by the mid-1990's.

I am distressed by the trend that we have seen in the DOE nuclear energy programs for the past 3 years because I believe that we are on the verge of losing many important energy options for our future.

While we may not choose to exercise some of these options, to disband and diminish our technical capabilities related to these options is inconsistent with the energy problems facing the Nation today.

Continuing on the present budgetary course, in my judgment, will insure that only one nuclear option will remain to us, and that will be the once-through fuel cycle for the light water reactor currently in use.

In reviewing the DOE budget with Assistant Secretary Cunningham today, I am sure that the members of the subcommittee will want to try to comprehend the rationale that the Department of Energy offers us in support of the major curtailments on practically all fronts of the nuclear energy efforts.

Now, with those words of encouragement, Mr. Secretary, I wonder if you would like to proceed with your statement.

STATEMENT OF HON. GEORGE W. CUNNINGHAM, ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY ROBERT L. FERGUSON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR ENERGY PROGRAMS; AND SHELDON MEYERS, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR WASTE MANAGEMENT

Mr. CUNNINGHAM. Thank you, Mr. Chairman. It is a pleasure to appear before you to discuss the Department of Energy's fission energy program within the context of the overall energy policy.

I am accompanied today by Mr. Robert Ferguson, Deputy Assistant Secretary for Nuclear Reactor Programs, and Sheldon Meyers, Deputy Assistant Secretary for Nuclear Waste Management.

My formal statement has considerable detail, so, with your permission, I would like to submit it for the record and begin my comments with a brief review of some of the events of the past year that have had a significant impact on the evolution of our nuclear policy, and then discuss a few points about our proposed program for fiscal year 1981.

Senator CHURCH. Very well.

Mr. CUNNINGHAM. Perhaps the foremost recent event was the accident at Three-Mile Island Nuclear Plant which occurred on March 28, 1979. As you know, the President established the Kemeny Commission to conduct a comprehensive study and investigation of the accident.

The resulting report included 44 recommendations for the improvement of nuclear safety. After analyzing the Commission's findings, President Carter has called for a cooperative effort on the part of Government and industry to strengthen their commitment to nuclear safety.

The DOE role in this mission is to work with the Nuclear Regulatory Commission, other Government entities, industry and the private sector as appropriate in helping to develop those corrective measures necessary for strengthening nuclear plant safety and reliability.

A second major issue that must be resolved is the question of disposal of nuclear waste material. I believe we have made significant progress in this area.

Last month, the President issued a policy statement announcing the Nation's first comprehensive program for radioactive waste management. The program is consistent with the broad consensus that evolved from earlier reports of the Interagency Review Group on radioactive waste management.

Its objective of insuring the safe storage and disposal of all forms of nuclear waste will be achieved through a strategy that is safe, technically sound, conservative, and open to continuous public review.

The policy statement calls for the preparation of a national plan for nuclear waste management, a draft of which will be published for congressional and public review later this year.

Mr. Chairman, we frequently emphasize in testimony such as this those things which we propose to do in the future rather than to report progress and achievements in programs for which you have already authorized and for which funds have been appropriated.

We can, indeed, report significant technical progress in spite of the issues regarding the future program. And I would like to describe a few of the achievements in the past 18 months.

Perhaps foremost among our recent accomplishments was the startup of the fast-flux test facility at Richland, Wash., on February 9, 1980.

With your permission, Mr. Chairman, I would like to show a brief videotape of this historic event and some related progress in other parts of the breeder program. It will take only a few minutes.

[Whereupon, a videotape was presented.]

Mr. CUNNINGHAM. I apologize again for the transmission. Nevertheless, we were quite pleased with achieving criticality at the FFTF. The reactor has continued to produce some excellent experimental work, particularly in the physics areas.

At this time, we are doing some modifications and preparing to proceed with the startup program to full power. We expect to achieve full power some time this fall.

Noteworthy accomplishments in other parts of the nuclear program include projects for improving uranium utilization, which have resulted in record high burnups; that is, in excess of 65,000 megawatt days per ton for light water reactor fuels.

We have initiated numerous safety efforts since Three-Mile Island, including substantial upgradings in personnel and equipment and the establishment of an Institute for Nuclear Power Operations by the industry, which DOE fully supports to assist individual utilities to strengthen their safety efforts.

We have made preparations for an underground test of 11 encapsulated spent fuel elements in a deep granite formation at the Nevada test site.

In our advanced isotope separation program, progress has been excellent. Many scientific and technical issues have been resolved, and we are now in a position to move forward to larger scale systems.

Turning now to fiscal year 1981, you have before you on page 5, a chart which compares the fiscal year 1981 request for fission energy research and development to the fiscal year 1980 appropriation. You will note significant shifts in the program priorities.

First, the overall emphasis is on fission energy's contribution in the near term with an increased funding request for light water reactor technology, advanced isotope separation and waste management programs.

Second, there is a sizable reduction in the request for the breeder program.

In addition, as you know, the President has submitted a revised fiscal year 1981 budget for the Department's programs. The impact of this revised budget on nuclear energy programs is shown in the table on page 7.

The proposed reduction to advanced reactor systems in fiscal year 1981 merely defers funding for longer term objectives in the reduced enrichment research and test reactor subprogram, which is the program for reducing the enrichment of fuel in research reactors.

In the area of commercial nuclear waste management, proposed reductions in the level of funding for remedial action activities in both fiscal year 1980 and fiscal year 1981 can be absorbed without impacting ongoing efforts at Manhattan Engineering District/Atomic Energy Commission sites for which the Department has clear authority to proceed.

However, there might be some delay in beginning remedial action at lower prioity sites which are contingent upon passage of pending enabling legislation.

Regarding the proposed deferral in fiscal year 1980 and reduction in fiscal year 1981 for advanced nuclear systems, these actions are in concert with an administration proposal to slip NASA's international solar-polar mission from 1983 to a 1985 launch date.

The overall effect of the proposed revisions to the gas-cooled breeder program will be to accelerate and complete most closeout activities in fiscal year 1980 instead of fiscal year 1981.

Finally, in the advanced isotope separation technology program, the combined fiscal year 1980 rescision and fiscal year 1981 reductions will reduce the level of effort in two areas.

For fiscal year 1980, the rescision will not affect the core research and development activities but will reduce basic research efforts relating to applications of the advanced isotope separation technology to the solution of other energy-related problems.

The proposed reduction of $3 million in budget authority and outlays for fiscal year 1981 will curtail work associated with the french chemical exchange process.

Mainline activities associated with the three major processes under development will be continued.

These reductions are not expected to seriously impede progress toward the President's three highest priority development efforts.

I would be pleased to answer any questions that you might have at this time, Mr. Chairman. And with that, I would conclude my oral testimony.

[The prepared statement of Mr. Cunningham follows:]

ORAL STATEMENT OF
GEORGE W. CUNNINGHAM
ASSISTANT SECRETARY
FOR NUCLEAR ENERGY
U.S. DEPARTMENT OF ENERGY
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATIONAL RESOURCES
U.S. SENATE

APRIL 23, 1980

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE, IT IS A PLEASURE TO APPEAR BEFORE YOU TO DISCUSS THE DEPARTMENT OF ENERGY'S FISSION ENERGY PROGRAM WITHIN THE CONTEXT OF THE OVERALL ENERGY POLICY. I AM ACCOMPANIED TODAY BY MR. ROBERT FERGUSON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS AND MR. SHELDON MEYERS, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR WASTE MANAGEMENT.

MY FORMAL STATEMENT HAS CONSIDERABLE DETAIL SO, WITH YOUR PERMISSION, I WOULD LIKE TO SUBMIT IT FOR THE RECORD. I WILL BEGIN MY COMMENTS WITH A BRIEF REVIEW OF SOME OF THE EVENTS OF THE PAST YEAR THAT HAVE HAD A SIGNIFICANT IMPACT ON THE EVOLUTION OF OUR NUCLEAR POLICY, AND THEN DISCUSS A FEW POINTS ABOUT OUR PROPOSED PROGRAM FOR FY 1981.

Perhaps THE FOREMOST RECENT EVENT

was the accident at the Three Mile Island nuclear plant which occurred on March 28. 1979 As you know, the President established the Kemeny Commission to conduct a comprehensive study and investigation of the accident. The resulting report included 44 recommendations for the improvement of nuclear safety. After analyzing the Commission's findings, President Carter has called for a cooperative effort on the part of government and industry to strengthen their commitment to nuclear safety.

The DOE role in this mission is to work with the Nuclear Regulatory Commission, other government entities, industry, and the private sector as appropriate in helping to develop those corrective measures necessary for strengthening nuclear plant safety and reliability.

A second major issue that must be resolved is the question of disposal of nuclear waste material. I believe that significant progress in this area has been achieved.

Last month the President issued a policy statement announcing the Nation's first comprehensive program for radioactive waste management. The program is consistent with the broad consensus that evolved from the earlier efforts of the Interagency Review Group on Radioactive Waste Management (IRG). Its objective of ensuring the safe storage and disposal of all forms of nuclear waste will be achieved through a strategy that is safe, technically sound, conservative and open to continuous public review. THE POLICY STATEMENT CALLS

FOR THE PREPARATION OF A NATIONAL PLAN FOR NUCLEAR WASTE MANAGEMENT, A DRAFT OF WHICH WILL BE PUBLISHED FOR CONGRESSIONAL AND PUBLIC REVIEW LATER THIS YEAR.

MR. CHAIRMAN, WE FREQUENTLY EMPHASIZE IN TESTIMONY SUCH AS THIS, THOSE THINGS WHICH WE PROPOSE TO DO IN THE FUTURE, RATHER THAN REPORT PROGRESS AND ACHIEVEMENTS IN PROGRAMS FOR WHICH YOU HAVE ALREADY AUTHORIZED AND APPROPRIATED FUNDS. WE CAN, INDEED, REPORT SIGNIFICANT TECHNICAL PROGRESS IN SPITE OF THE ISSUES REGARDING THE FUTURE PROGRAM. I WOULD LIKE TO DESCRIBE A FEW ACHIEVEMENTS IN THE PAST 18 MONTHS.

PERHAPS FOREMOST AMONG OUR RECENT ACCOMPLISHMENTS WAS THE STARTUP OF THE FAST FLUX TEST FACILITY (FFTF) AT RICHLAND, WASHINGTON, ON FEBRUARY 9, 1980. WITH YOUR PERMISSION, MR. CHAIRMAN, I WOULD LIKE TO SHOW THE COMMITTEE A BRIEF VIDEOTAPE OF THIS HISTORIC EVENT. AND SOME RELATED PROGRESS IN OTHER PARTS OF THE BREEDER PROGRAM.

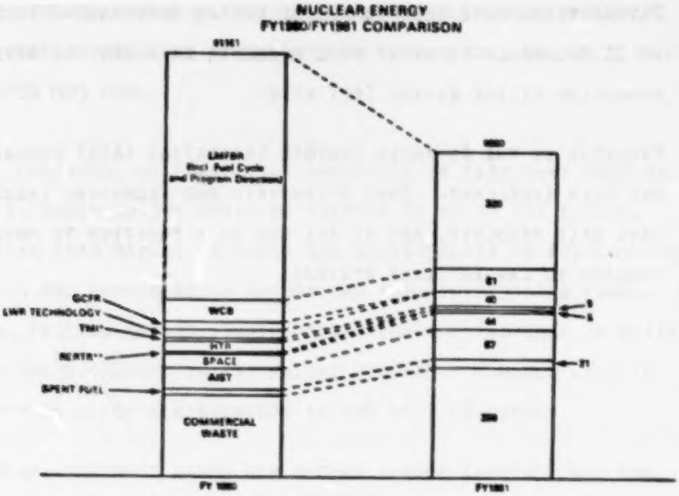
NOTEWORTHY ACCOMPLISHMENTS IN OTHER PARTS OF THE NUCLEAR PROGRAM INCLUDE:

- PROJECTS FOR IMPROVING URANIUM UTILIZATION HAVE RESULTED IN RECORD HIGH BURNUP LEVELS FOR LIGHT WATER REACTOR FUELS.

- NUMEROUS SAFETY EFFORTS HAVE BEEN INITIATED SINCE TMI INCLUDING SUBSTANTIAL UPGRADINGS IN PERSONNEL AND EQUIPMENT AND THE ESTABLISHMENT OF AN INSTITUTE FOR NUCLEAR POWER OPERATIONS, WHICH DOE FULLY SUPPORTS TO ASSIST INDIVIDUAL UTILITIES IN THEIR STRENGTHENING EFFORTS.

- Preparations have been completed for an underground test of 11 encapsulated spent fuel elements in a deep granite formation at the Nevada Test site.

- Progress in the Advanced Isotope Separation (AIS) program has been excellent. Many scientific and technical issues have been resolved, and we are now in a position to move forward to larger-scale systems.



*Supplemental request
**Includes supplemental request

Turning now to FY 1981, this chart compares the FY 1981 budget request for fission energy research and development to the FY 1980 appropriation. You will note significant shifts in program priorities. First, the overall emphasis is on fission energy's contribution in the near term, with an increased funding request for LWR technology, advanced isotope separation, and waste management programs. Secondly, there is a sizable reduction in the request for the breeder program.

As you know, the President has submitted a revised FY 1981 budget for the Department's programs. The impact of this revised budget on Nuclear Energy programs is shown in the following table.

The proposed reduction to Advanced Reactor Systems in FY 1981 merely defers funding for longer-term objectives in the Reduced-Enrichment Research and Test Reactor subprogram. In the area of Commercial Nuclear Waste Management, proposed reductions in level of funding for Remedial Action activities in both FY 1980 and FY 1981 can be absorbed without impacting ongoing efforts at Manhattan Engineering District/Atomic Energy Commission sites for which the Department has clear authority to proceed. However, there might be some delay in beginning remedial action at lower priority sites which were contingent upon passage of pending enabling legislation. Regarding the proposed deferral in FY 1980 and reduction in FY 1981 for Advanced Nuclear Systems, these actions are in concert with an Administration proposal to slip NASA's International Solar Polar mission from a 1983 to a 1985 launch date. The overall effect of the proposed revisions to the Gas Cooled Breeder Reactor Program will be to accelerate and complete most closeout activities in FY 1980, instead of FY 1981.

Finally, in the Advanced Isotope Separation Technology Program, the combined FY 1980 rescission and FY 1981 reductions will reduce the level of effort in two areas. For FY 1980, the rescission will not affect the core R&D activities, but will reduce basic research efforts related to applications of AIST to the solution of other energy-related problems. The proposed reduction of

NUCLEAR ENERGY PROGRAMS
(DOLLARS IN MILLIONS)

	FY 1980	REDUCTION FY 1980	CONGRESS. BUDGET FY 1981	REDUCTION FY 1981
NUCLEAR REACTOR PROGRAMS				
CONVERTER REACTOR SYSTEMS	65.8		54.9	-2.0
BREEDER REACTOR SYSTEMS	761.8	-8.0	384.0	-0.8
ADVANCED NUCLEAR SYSTEMS	39.6		43.9	-2.0
ADVANCED ISOTOPE SEPARATION TECH.	55.7	-1.0	86.9	-3.0
TOTAL NUCLEAR REACTOR PROGRAMS	922.9	-9.0	569.7	-7.8
NUCLEAR WASTE MANAGEMENT				
DEFENSE WASTE MANAGEMENT	283.4	-3.4	349.7	-13.0
COMMERCIAL WASTE MANAGEMENT	220.1		298.9	-10.0
SPENT NUCLEAR FUEL	18.5		20.5	
TOTAL WASTE MANAGEMENT	522.0	-3.4	669.1	-23.0
TOTAL NUCLEAR ENERGY PROGRAMS	1444.9	-12.4	1238.8	-30.8

$3.0 MILLION IN BUDGET AUTHORITY AND OUTLAYS FOR FY 1981 WILL CURTAIL WORK ASSOCIATED WITH THE FRENCH CHEMICAL EXCHANGE PROCESS. MAINLINE ACTIVITIES ASSOCIATED WITH THE THREE MAJOR PROCESSES UNDER DEVELOPMENT WILL BE CONTINUED. THESE REDUCTIONS ARE NOT EXPECTED TO SERIOUSLY IMPEDE PROGRESS TOWARDS THE DEPARTMENT'S THREE HIGHEST PRIORITY DEVELOPMENT EFFORTS.

IF THERE ARE ANY QUESTIONS, I WOULD BE PLEASED TO ANSWER THEM AT THIS TIME.

Statement of
George W. Cunningham
Assistant Secretary
for Nuclear Energy
U.S. Department of Energy
Before The
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U.S. Senate

April 23, 1980

Mr. Chairman and Members of the Committee, it is a pleasure to appear before you to discuss the Department of Energy's nuclear fission energy program. The funding request for nuclear fission energy research and development for FY 1981 is $890 million in budget authority, compared to $1,162 million in FY 1980. The funds are distributed among the program elements as follows:

	FY 1980	FY 1981
Converter Reactor Systems	$ 66	$ 55
Advanced Isotope Separation	56	87
Breeder Reactor Systems	762	384
Advanced Nuclear Systems	40	44
Commercial Nuclear Waste	220	299
Spent Nuclear Fuel	18	21
Total Fission Energy	$1162	$ 890

I would like to review briefly the nuclear policy directing the R&D planned by DOE for FY 1981 and beyond, and then outline the programs we have designed to implement this policy.

Growing concern over the severe implications of our continued dependence on foreign sources of oil has led to a National Energy Plan designed to ensure a future where energy supplies will be secure from foreign instability and interruption. This Plan, which was presented to Congress in May of last year, calls for a combination of measures to achieve our goal of energy independence, including conservation, substitution of more abundant sources of energy for those in short supply, and development of advanced technologies for the future.

Even with the most successful of efforts, the advanced technologies now under intensive development, such as solar energy, synthetic fuels and fusion energy, will not be able to meet all the projected requirements of the next two decades. In light of diminishing oil supplies, nuclear and coal are considered to be the two principal energy sources capable of meeting the expansion of U.S. electrical energy needs for the remainder of this century. Sound energy planning demands the aggressive development and utilization of both options as transitional fuels, for the loss of either as an available source of supply during the next 20 years could result in an accelerated rise in oil imports and insufficient electric generating capacity to meet our needs.

To ensure that nuclear energy fulfills this role as an important transitional fuel, it is essential that our efforts incorporate the resolution of three issues confronting continued utilization. The first area of concerted effort must be to improve the safety and reliability of nuclear power generation. Although safety has always been a paramount consideration of nuclear development, the accident at Three Mile Island dramatically focused our attention on the need for further improvement. We are satisfied that the accident was contained with no appreciable detrimental offsite effects; however, we are mindful of the economic loss, the loss of available power and the technical and institutional problems which the accident and the subsequent investigations have revealed.

As you know, on April 11, 1979, President Carter established the Kemeny Commission to conduct a comprehensive study and investigation of the accident. After analyzing the Commission's findings, President Carter has called for a cooperative effort on the part of government and industry to strengthen their commitment to nuclear safety. The specifics of this coordinated effort involve the reform of various aspects of the organization, procedures, and practices of the nuclear community.

The DOE role in this mission is to work with the Nuclear Regulatory Commission, other government entities, industry, and the private sector, as appropriate, in helping to develop corrective measures necessary for strengthening nuclear plant safety and reliability. These measures--many of which have already been implemented--are designed to improve the safety and reliability of nuclear reactors in such a way as to encourage public confidence in and acceptance of nuclear energy.

A second major issue related to nuclear power is the question of disposal of nuclear waste material. We feel that significant progress in this area has been achieved. Last month the President issued a policy statement announcing the Nation's first comprehensive program for radioactive waste management. The program is the outgrowth of the broad concensus that evolved from the earlier efforts of the Interagency Review Group on Radioactive Waste Management (IRG). Its objective of ensuring the safe storage and disposal of all forms of nuclear waste will be achieved through a strategy that is safe, technically sound, conservative and open to continuous public review. The programs designed to implement the strategy are either already part of our ongoing programs or are reflected in DOE's FY 1981 budget request that we are discussing today.

Still another concern requiring consideration is the proliferation issue. During the past year we have made significant advances in this area through two comprehensive studies -- one domestic and one international.

The draft Non-Proliferation Alternative Systems Assessment Program (NASAP) report prepared by DOE was offered for public comment on December 14, 1979. This report will be published in final form later this year. Similarly, the International Nuclear Fuel Cycle Evaluation (INFCE) was conducted during the past two years by 71 nations and international agencies. The final plenary session was held late last month.

NASAP studies have reaffirmed that there is no purely technical fix to the proliferation potential of the nuclear fuel cycle; however, both technical and institutional improvements can be made. The LWR operating on a once-through fuel cycle has acceptable nonproliferation characteristics. On the other hand, improved institutional arrangements, and particularly improved international safeguards, would be required for the sensitive reprocessing and refabrication steps of the fuel cycle. Another finding of importance is that reprocessing for the purpose of recycling plutonium in thermal reactors is not likely to be cost effective, a view shared by the major nuclear nations.

There appears to be general agreement among many countries that the breeder reactor option should be kept open. However, in view of uncertainties in uranium availability and breeder reactor system costs, there is disagreement regarding the need and timing of breeder deployment. Since breeder technology is relatively complex and difficult, those countries considering breeder development should have a viable reactor technology support system, including operating thermal reactors, in place before moving into the breeder reactor system.

The research and development programs contained in the FY 1981 budget will continue to couple the improvement of the present generation of nuclear reactors -- the LWR -- with prudent and responsible long-range planning for the next generation of nuclear technology -- the essentially inexhaustible resource represented by the breeder reactor. As you know, in April 1977 the Administration deferred commercialization of the breeder based on a a decline in LWR orders, an anticipated reduction in the growth in demand for electrical energy in the next decades and an increased sensitivity to proliferation concerns. This policy redirection has afforded time not only to restructure the breeder program so as to ensure the most beneficial development of this complex technology but has also permitted the concentration of our efforts on establishing a strong LWR system. This programmatic emphasis is imperative if we are to achieve the near-term role for nuclear as one of the two principal energy sources for meeting U.S. electrical energy needs over the next two decades.

I would now like to discuss the objectives, strategies, and status of the individual program elements.

CONVERTER REACTOR SYSTEMS

The Converter Reactor Systems Program is concerned with the safe, economic, and productive utilization of the light water reactor (LWR), which is the type of reactor currently producing almost all of the nuclear energy commercially available in the United States. In addition to LWR technology and safety, I will discuss the Three Mile Island examination activities and our efforts in developing advanced reactor systems. The funding request for these activities for FY 1981 is $55 million in budget authority, compared to $66 million in FY 1980.

THERMAL REACTOR TECHNOLOGY

This budget category is concerned with two activities--the High Temperature Reactor and Light Water Reactor Technology. The budget request for FY 1981 is $40 million in budget authority, compared to $50 million in FY 1980.

High Temperature Reactor

A FY 1980 budget item that was not repeated for FY 1981 is the High Temperature Reactor Program element. DOE has provided the primary funding support for continued development of the High Temperature Gas Cooled Reactor since private sector funding for this program began to diminish in 1975. Current national fiscal priorities preclude further funding of the High Temperature Reactor program.

The potential benefits as compared to the total development costs that would be required to commercialize high temperature gas systems, are highly uncertain. The recently completed NASAP study indicates that the potential savings in total power cost with HTRs as compared to improved LWRs are marginal and have considerable uncertainties. Furthermore, the study indicates that for any of the unique high temperature applications considered, no significant market can be expected before well after the turn of the century. Total reactor system development and demonstration plant costs were estimated to be in the range of 4 to 5 billion dollars; in addition, there would be significant costs required for associated fuel cycle development and related facilities. As a result, after careful consideration of the many factors involved, including national fiscal constraints, further government support of HTR development beyond FY 1980 will be indefinitely deferred. Federal support of these activities is proposed to be brought to an orderly conclusion in FY 1981. Work accomplished will be carefully documented so that all information will be available for possible future use.

pages tightly bound

Light Water Reactor Technology

The Light Water Reactor Technology program involves the development and demonstration of technology which can be used by utilities to improve the utilization of uranium in LWRs, reduce occupational radiation exposures and improve nuclear plant productivity - all of which help foster government policies relative to the use of LWRs.

Nuclear power plants - almost exclusively of the light water reactor type - are presently providing approximately 12% of the U.S. electrical energy needs, and this share is expected to increase significantly in the years ahead. There are now seventy-two central station nuclear plants licensed to operate in the U.S. with an installed electrical capacity of 52,500 megawatts electric (MWe). By the year 2000, the U.S. nuclear power capacity is projected to be in the range of 235,000-300,000 MWe, and these plants should be providing about 30% of the Nation's electrical energy. DOE's LWR technology program efforts will be important in ensuring that nuclear power plants play the critical role expected of them in helping to meet future energy requirements.

Implementation of the LWR Technology Program serves to advance several major policies. The objective of improving uranium utilization in LWRs is in direct support of the Administration's nonproliferation policies and reflects the Administration's indefinite deferral of spent fuel reprocessing. Efforts to reduce occupational radiation exposure support the government policy of minimizing the incidence of adverse radiation exposure. In furtherance of National Energy Plan goals, improving nuclear plant productivity reduces dependency on foreign oil for the generation of replacement electricity.

The program is carried out through multiple cost-shared efforts with industry aimed at the development and in-plant demonstration of improved technologies. The projects are implemented by having electric utilities as prime contractors, with equipment suppliers/ fuel vendors as subcontractors. This approach enhances and accelerates the R&D and assures the commercial applicability and rapid implementation of the improved technologies.

Uranium Utilization--The objective of this program element is to develop and demonstrate technology for significantly reducing LWR uranium resource requirements. Demonstration of technology which would permit a 15% reduction is projected for 1988, and a 30% savings might be shown to be achievable by the year 2000.

The Department now has underway a high priority effort for developing and demonstrating uranium utilization improvements. The program has four major parts.

(a) Development and demonstration of higher burnup fuel - this is the most important near-term method for substantially improving uranium utilization.

(b) Development of other backfittable improvements (those which can be readily utilized in existing plants).

(c) Supporting research and development to provide the technical basis for high burnup fuel design.

(d) Examination of non-backfittable reactor design features (those which involve major plant changes and are therefore practical only in new plants).

Substantial progress is being made in all four of these areas. High burnup fuel projects are now underway with four of the five U.S. fuel vendors with utility partners; a project with the fifth U.S. fuel vendor with a utility partner is in the final stages of negotiations. A burnup level of 40,000 MWD/MTU has been achieved

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for five fuel assemblies in Duke Power's Oconee reactor - a new record for Babcock and Wilcox fuel. Detailed planning and design is underway for other near-term backfittable improvements for both PWRs and BWRs. Two major new projects have been initiated: one with the Sacramento Municipal Utility District (SMUD) for the development and demonstration of an axial blanket fuel design and the other with TVA for the investigation of eight other promising methods for improving uranium utilization.

In the supporting research and development program, progress continues in the development of design solutions for alleviating pellet-clad interaction (PCI) in LWR fuel. Two major projects, involving Commonwealth Edison Company and Consumers Power Company and their respective subcontractors, are well along. The second phase of a project directed at investigating fission gas release in high burnup fuel will be initiated soon. Additional projects are under contract negotiation or are being planned.

Work has commenced on the Advanced Reactor Design Study; this is being managed by Battelle Pacific Northwest Laboratories and includes participation by the reactor vendors. Upon completion of the study, decisions will be made on its continuation in terms of further design effort and/or hardware development and demonstration.

The funding requested for FY 1981 will be used to:

- Continue the projects directed toward developing and demonstrating high burnup fuel.
- Continue several projects directed at developing and demonstrating methods other than high burnup for improving uranium utilization, including the projects with Sacramento Municipal Utility District and TVA.

- Continue the technology development and demonstration projects in support of high burnup on concerns such as PCI and fission gas release. Included are the two PCI projects with Commonwealth Edison and Consumers Power, respectively, as prime contractors; a project with Exxon Nuclear Company directed at developing sphere-pac technology; and the internationally sponsored fission gas investigation.
- Complete the Advanced Reactor Design Study.
- Initiate selected new projects, primarily in support of the longer range improvements, to enhance uranium utilization.

Occupational Radiation Dose Reduction/Productivity Improvement-- The objectives of these program elements are to develop and demonstrate technology which will (a) significantly lower radiation exposures to nuclear plant workers and (b) improve LWR plant productivity. Almost all projects within these two program elements serve to further significantly both of these objectives, and hence their budgeting and management are undertaken together.

Worker radiation exposures will be lowered by (a) reducing the sources of radiation through chemical decontamination and contamination prevention techniques, (b) keeping workers' time in radiation areas to a minimum through the use of diagnostic and surveillance techniques and improved operating and maintenance practices, and (c) other approaches being identified in a Radiation Exposure Management (REM) study.

LWR plant productivity will be improved by treating known problems in present LWR components and systems as well as by diagnosing and monitoring the impact of future problems which may arise. The expanded productivity effort could yield an improvement of 5% in productivity within 10 years, resulting in an actual oil savings on the order of 30 million barrels per year (assuming an installed capacity of 140,000 MWe and 40% of actual replacement power originating from oil-fired stations).

In the radiation reduction element, initial projects on dilute decontamination methods and alternate water chemistry technologies for BWRs have been completed. A thorough decontamination process to be applied at the Dresden 1 BWR in April 1980 will demonstrate removal of radiation sources in older and highly contaminated BWRs. A feasibility study on approaches to PWR primary system decontamination has been completed. A project has been initiated for demonstrating radioactive decontamination techniques for contaminated components from the Three Mile Island plant.

In the diagnostic and surveillance area, an acoustic emission monitoring (AEM) project with Consolidated Edison has been successfully completed; this project has involved the development of an AEM system for total pressure-boundary surveillance in PWRs. Work on an AEM project with the Philadelphia Electric Company is continuing; this project is directed at the development of an AEM system for surveillance of key components in BWRs. An additional surveillance and diagnostic project involving development of a rotating equipment monitoring system has been initiated with the Middle South Energy, Inc. as the prime contractor. Middle South Energy, Inc. is the holding company and contracting agent for a number of utilities, including Mississippi Power and Light which is the utility actually conducting the project. The REM study, which is being used to help develop an overall radiation reduction plan, is well underway; Catalytic Inc. is the contractor for this project.

In the productivity improvement area, two major projects are underway to help resolve known problems in LWR plants. One of these involving Commonwealth Edison Company as the prime contractor is directed at preventing or alleviating "denting" in steam generators. Denting is caused by the buildup of corrosion products in the annuli between the steam generator tubes and tube support plates to the point where significant force is exerted on the tube, causing it to dent. A second project, involving General Electric Co. as the prime contractor, is directed at preventing flow induced vibration failures of reactor plant components.

The funding requested for FY 1981 will be used to:

- Continue FY 1980 surveillance and diagnostic projects.
- Continue and initiate new projects directed at developing techniques for chemical decontamination and contamination prevention.
- Initiate new promising projects identified in the REM study and a corresponding productivity study.
- Continue/initiate projects directed at preventing or alleviating steam generator denting effects.
- Initiate projects to shorten the duration of scheduled nuclear plant outages and to reduce worker radiation exposure during such outages.

Light Water Reactor Safety Technology--The objective of the LWR safety technology activities is to develop and encourage the implementation of technology to reduce nuclear accident risks.

Emphasis will be placed on the prevention of serious accidents through a disciplined use of a defense in-depth, which focuses attention on the reliability of operating equipment and backup safety systems that impede the progression of serious accidents.

Improvements in LWR safety, which have been called for by those groups which have investigated the Three Mile Island accident, will improve the LWR licensing and the public acceptance of LWRs, thereby reducing impediments to the increased utilization of this valuable domestic energy resource.

The work is structured in four program areas:

First, Improved Systems which include the development and improvement of equipment and systems which offer significant improvements in safety through increased reliability and better performance.

Second, Man-Machine Interface which includes the utilization of computer technology to assist the operator on the control of normal operation and in responding to off-normal and emergency operations.

Third, the development of Risk-Based Methods and the use of these methods to help select R&D tasks and establish priorities.

Fourth, the acquisition of Safety Data to support safe reactor operations and assist in the resolution of generic safety items.

The work is accomplished through a multicontractor program involving industry, university and national laboratory participants.

In FY 1981, work in the Improved Systems area will be initiated on detailed design and evaluations for advanced decay heat removal systems, improvement of components important to safety and improved containment features. In the Man-Machine Interface area, specific design tests and analysis activities will be initiated on the disturbance analysis and surveillance system. In the Risk Methods Utilization area, applications of the techniques developed in FY 1979 and FY 1980 will be initiated. In the Safety Data area, the evaluation of containment sump vortex suppression devices will be completed.

The increased budget request for FY 1981 relative to FY 1980 will permit specific safety improvements on a number of aspects of LWR plant design and operation, and will provide for greater dissemination of the experience developing from the TMI-2 accident.

The work is coordinated with complementary work in safety research sponsored by the Nuclear Regulatory Commission. The DOE emphasis is to develop technology for accident prevention, whereas NRC's major research programs are directed to confirm safety margins. Industry input is sought on the work to be performed and, where appropriate, projects are cost shared with industry. The work is coordinated with that of the Electric Power Research Institute and other organizations, as well as with the programs of other countries.

THREE MILE ISLAND ACTIVITIES

As part of the Department's FY 1981 budget submittal, a supplemental request of $7 million for FY 1980 is included for the Three Mile Island Examination program. The request for FY 1981 is $9 million. DOE has proposed to embark on this new activity as a result of the accident at Three Mile Island Unit 2 on March 28, 1979. The proposed program will obtain data from the cleanup, examination and evaluation of the TMI plant and equipment that will be of great value in improving the reliability and safety of future nuclear power plants and in improving the capability to safely recover nuclear plants from accidents.

The nuclear industry and the Nuclear Regulatory Commission have the principal responsibility for extracting the lessons learned from Three Mile Island and incorporating them into ongoing operations and regulations. Numerous efforts have been initiated since the accident including substantial upgradings in personnel and equipment at individual nuclear power plants and establishment of an Institute for Nuclear Power operations to assist individual utilities in their strengthening efforts. DOE has the very important responsibility of supporting both the industry and NRC efforts with technical expertise and resources that reside within the Department.

The specific areas where DOE can best contribute are being evaluated and will emerge from ongoing dialogue with NRC and industry officials. However, one responsibility has been already defined in an agreement between NRC and DOE. DOE, NRC, the Electric Power Research Institute (EPRI), and General Public Utilities (GPU) have agreed to participate in a joint TMI information and examination program. The four parties have agreed to conduct the program in such a manner so as not to delay the cleanup and recovery efforts to be completed by GPU. The participants have also agreed to avoid conducting any work that is the responsibility of the utility owners of TMI Unit 2. During the normal course of its cleanup and recovery operations on TMI Unit 2, it is inevitable that GPU will develop a portion of the data available in TMI Unit 2 which is of generic value to nuclear energy technology. The Joint DOE/NRC/EPRI/GPU program will obtain an increment of generic data beyond this base. DOE and NRC have agreed that DOE would have the lead government role and any government funding would be provided from the DOE budget.

The objectives of this program are:

- To obtain significant applicable information stemming from the TMI Unit 2 accident and make this information available for the general improvement of light water reactor plant safety and reliability, both in the U.S. and abroad.
- To integrate unique data and experience from TMI Unit 2 into ongoing government and EPRI research and development programs as may be beneficial.
- To make most effective use of the combined resources of government and industry.
- To gain experience from the return of TMI Unit 2 to safe commercial operation and make this knowledge generally available to others engaged in the design, construction, operation and maintenance of nuclear power plants both here and abroad.

Onsite efforts will be conducted at TMI (near Harrisburg, Pennsylvania). The location of off-site efforts will be identified when planning efforts are completed.

At present, seven major tasks will be completed in this program. These tasks are: Instrumentation and Electrical Equipment Survivability; Radiation and Environment; Radioactive Waste Handling; Physical Plant Examination; Data Integration, Storage, Archives; Mechanical and Structural Components; and Reactor Core and Fuel. Additional tasks will be added as appropriate.

The objective of this program is to make these data available both in the U.S. and internationally through workshops, seminars, progress reports and final reports. This activity will be designed to maximize the transfer of technology from task performers to users of the technology.

FY 1980 DOE activities currently being planned include preliminary testing of electrical equipment from outside the containment to determine its performance, acquiring physical and environmental data during initial entry by the owner into containment and from samples removed from containment, and developing the special sampling and testing equipment needed to acquire data. Additional tasks are expected to be identified when planning efforts are completed.

The FY 1981 budget request for the Three Mile Island Examination Activities will continue the efforts initiated in FY 1980.

ADVANCED REACTOR SYSTEMS

This activity consists of only the Reduced-Enrichment Research and Test Reactors (RERTR) program in FY 1981 because the Advanced Nonproliferation Reprocessing Technology (ANRT) activities, which comprised the other component in FY 1980, will be placed in the Fuel Cycle R&D program, Breeder Systems budget at the end of FY 1980. A FY 1980 supplemental budget request for the ANRT program accompanies the FY 1981 budget submission. This request is for $2,500,000 in capital equipment funds for in-plant systems that can significantly increase the diversion resistance of fuel cycle operations by reducing human access to process equipment and operations involving fissile material and by improving the capability to remotely monitor operations and to obtain conclusive information regarding diversion threats or covert plant modification. In FY 1980, key equipment components will be procured to test remote maintenance and sampling concepts.

The budget request for the RERTR program is $5 million in FY 1981, as it was in FY 1980. The objectives of the RERTR program is to develop and demonstrate technology for reducing uranium enrichment in research and test reactor fuels so as to reduce the associated proliferation risks, and to facilitate international use of such reduced-enrichment fuels, thereby effecting a reduction in U.S.-supplied highly enriched uranium (HEU) inventories abroad.

The near-term objective of the program is to use current technology to achieve the lowest feasible fuel enrichment. Fuel fabrication technology currently available in the U.S. and in Europe permits enrichment reduction from 90-93% to 30-45% in many reactors and to as low as 20% in others.

The long-term objective of the program is to develop high-uranium-density fuel technology to permit enrichment reductions to below 20% in almost all research and test reactors. An equally important long-term objective is to provide the technical support necessary to make the high-uranium-density fuels commercially available, although the deployment of reduced enrichment uranium (REU) fuels in research reactors is not part of the RERTR Program activities.

The numerous offers from reactor operators and fuel fabricators to participate in the RERTR Program activities and the creation of similar RD&D programs in Japan, France and Germany would indicate foreign acceptance of the REU-fuel concept. Commercial fuel fabricators already have demonstrated that significant increases in the U-density of MTR-type fuels can be achieved by minimal modifications in current fabrication procedures, such that most low power density reactors should convert to an LEU fuel, and they feel confident that further advances in this capability will be achieved.

In FY-1981, DOE will (1) continue to develop advanced fuels with increased uranium content, thereby facilitating reduction of uranium enrichment requirements, (2) begin irradiation demonstrations of reduced-enrichment fuels in selected research and test reactors and (3) continue to provide the assistance requested by reactor operators involved in the study and implementation of conversions of their reactors to REU fuels.

Through DOE-supported research, development and demonstration, commercial fuel fabricators should be in a position by 1983 to offer REU fuels which can replace the HEU fuels now being used in almost all of the low-power research and test reactors which depend on the U.S. for the HEU. Specific activities to be carried out in FY-1981 include:

1. Characterize related neutron flux spectra and implement operation at power levels suitable for fuel performance verification of the full core of plate-type low enrichment uranium (LEU) fuel in the Ford Nuclear Reactor (FNR at U. Mich.);

2. Install a full core of TRIGA-type LEU fuel in the Rhode Island Nuclear Science Center (RINSC) reactor and implement operation at power levels suitable for fuel performance verification;

3. Continue advanced fuels technology including miniplate irradiations of aluminide, oxide and silicide REU fuel materials, and initiate postirradiation examination and evaluation studies; and

4. Continue to provide technical assistance in response to requests from reactor operators who are evaluating the convertibility of their reactors to use of REU fuels.

ADVANCED ISOTOPE SEPARATION

I would now like to discuss the Advanced Isotope Separation (AIS) Program. The budget request for this program in FY 1981 is $87 million in budget authority, compared to $56 million in FY 1980.

I am particularly happy to report to you that progress in the AIS Program continues to be excellent. As a result, we are now in a position to move forward to larger scale systems, which is reflected in our budget request for FY 1981. Many scientific and technical issues have been resolved. The remaining scientific issues and the engineering aspects of the technologies can best be solved by going to larger systems.

The next major objective of the AIS Program strategy involves the development and operation of semi-integrated testbed systems, which we have called preprototype systems. The preprototype systems will demonstrate the scientific principles of the AIS technologies using scaled-up components. The preprototypes should be completed by the end of FY 1981, at which time comprehensive economic, technical, and environmental evaluations of the techniques will be initiated to determine if the available data warrant proceeding to full engineering development. Assuming a decision is made to proceed with engineering development, an engineering Development Module (DM) could be operational in the mid-1980's. The operation of this module would demonstrate a fully integrated process with sufficient reliability to develop a firm basis for determining production costs. In addition, the Development Module would be used to explore the off-design operating performance of the technology.

Because of classification, I cannot now discuss the key accomplishments and future specific milestones of the program. We have, however, met with the Committee staff members to inform them of the program's progress and would be happy to provide the Committee with additional information on a classified basis as desired.

During FY 1981, efforts will be concentrated on the final integration of large-scale components into, and operation of, preprototype testbed systems. The preprototype systems require lasers of higher power and repetition rate than have been previously operated, larger magnet systems, and larger source and extractor subsystems. One of the major objectives of the preprototype systems will be to identify any scaling issues which could be associated with the AIS technologies.

The molecular process has been under development at the Los Alamos Scientific Laboratory. Major efforts have been directed toward (1) increasing the basic understanding of the interaction of the process gas and laser energy, (2) acquiring the infrared and ultraviolet lasers to be used in the large testbed, and (3) increasing the average power output per laser and increasing the lifetime of the lasers. Although much progress has been made, some science issues for the molecular process remain concerning the interaction of the laser energy and the process gas.

The atomic vapor process has been under investigation at the Lawrence Livermore Laboratory. Work has stressed (1) developing lasers having higher average power output per laser and longer lifetimes, (2) increasing the lifetime of materials exposed to liquid uranium and uranium vapor, and (3) developing an extractor capable of operating at the densities required for a production module. Design and fabrication of the uranium handling system began in FY 1979. The uranium handling system includes both the uranium vapor source and the structure required for the transport of uranium.

The plasma process has been under development by TRW, Inc. Major efforts have been directed toward (1) increasing the routine operation of scalable plasma sources, (2) establishing the scaling laws and increasing the scientific knowledge of the plasma process, and (3) developing materials for collectors that have the necessary properties and lifetimes. Some science questions on the plasma process remain to be resolved. In FY 1979, a larger magnet system began operation which has led to increased knowledge of the process science and scaling parameters.

The preprototype testbeds will be operated for approximately six months before a decision is made to proceed to the engineering development phase of the program. We believe that the operation of this facility and the successful completion of the Development Module in the mid-1980's will permit the introduction of an AIS production capability in the early 1990's.

In addition to developing the advanced technologies, there is a renewed interest in the uranium chemical exchange process because of its perceived proliferation resistance. At DOE's Mound Facility, increased efforts are being directed at establishing a firm understanding of the process parameters. In FY 1974, a Protocol Agreement for cooperation in this area was signed with the Republic of France. The U.S. has now received data and information which will be used to evaluate the proliferation resistance and economic potential of the French Chemical Exchange Process. In FY 1980, a bench-scale facility will become operational at Mound Facility which will have the capability of verifying laboratory-developed process parameters in an integrated system.

BREEDER REACTOR SYSTEMS

The objective of the Breeder Reactor Systems Program is to develop a base of data that could be used to demonstrate the breeder concept as a possible option in planning for essentially inexhaustible energy supplies. The program is concerned with three types of breeder reactors--the Liquid Metal Fast Breeder Reactor, the Water Cooled Breeder, and the Gas Cooled Fast Reactor--as well as their fuel cycles. The budget request for this activity for FY 1981 is $384 million in budget authority, compared to $762 million in FY 1980.

LIQUID METAL FAST BREEDER REACTOR PROGRAM

Two major changes in the LMFBR program for FY 1981 involve a decrease of $172 million by the proposed termination of the Clinch River Breeder Reactor Plant Project as well as a reduction of $66 million in the base technology program. Other smaller changes make the total reduction $315 million.

The Administration is proposing to continue a broad based LMFBR development program aimed at advances in critical technical areas, i.e., sodium heat transport systems, fuels, safety and proliferation resistant breeder reprocessing technology.

The objective of the LMFBR program is:

> To continue to develop technical and engineering information on the LMFBR concept to provide the basis for a future decision on when to proceed with further plant development and deployment.

The program emphasizes completion of the Fast Flux Test Facility (FFTF), the most advanced test bed for advanced breeder fuel concepts in the world; and completion of a conceptual design study (CDS) for a developmental plant that could serve as the next logical step in the LMFBR development and deployment process.

I am pleased to announce that FFTF reached initial criticality--that is, a self sustaining chain reaction--on February 9 of this year. We will continue a careful, systematic preoperational checkout phase for the next year prior to full power operation. Achievement of initial criticality is of major importance in confirming the nuclear systems design leading to readiness of the reactor for program service.

Some other key accomplishments over the past year have been:

- o Conceptual Design Study contractors were selected and Phase I of study proceeded on schedule.
- o Studies on liquid metal pumps and intermediate heat exchangers for pool type reactors were completed.
- o Steam generator recirculating studies were completed.
- o Criticality experiments provided confirmation of the neutronic and safety related characteristics of CRBRP-sized plants.

- EBR-II tests of reference materials, oxide fuel and absorbers provided assurance for proceeding with currently planned operation of FFTF.
- The capacity of the Sodium Components Test Installation at the Energy Technology Engineering Center was increased from 35 to 70 megawatts thermal to permit the testing of large steam generators and heat exchangers.

Fast Flux Test Facility

The major operating facility of the LMFBR program is the Fast Flux Test Facility (FFTF), a 400 megawatt thermal sodium-cooled, fast-neutron-flux reactor facility specifically designed for irradiation testing of breeder reactor fuels and materials. It is located at the Hanford Engineering Development Laboratory near Richland, Washington. Major construction of this facility was completed in September 1978, sodium fill was completed in December 1978, and criticality was achieved in February 1980.

An extensive five phase acceptance testing program has been underway for more than two years and is continuing as a prerequisite for bringing the facility to a fully operational status. Currently, we are in the fourth phase of this acceptance testing program which involves loading the reactor fuel.

In fulfilling its prime role of providing a test bed for demonstrating and evaluating the performance of future LMFBR-plant fuel assemblies and core designs at reference conditions, the FFTF will be used:

- To test fuel elements up to and including failure under dynamic sodium-flow conditions in order to establish ultimate capability and failure modes--an understanding of failure modes is essential to establish LMFBR core safety, reliability, performance, and lifetimes;

- To develop the advanced fuels and advanced cladding and duct materials essential to attaining operational breeding ratios in the 1.25 to 1.45 range with fuel doubling times of less than 15 years;
- As a prototype irradiation test bed for various fast reactor fuel and blanket materials considered in the nonproliferation fuel cycle studies, and
- To obtain experience in the operation of an LMFBR having coolant loops and components at operating conditions typical of large LMFBR power plants.

FY 1981 funding will provide for:

- Ascent to power and the initial power demonstration run to confirm operational plant characteristics.
- Plutonium conversion costs for materials for the FFTF and associated development programs.
- Acquisition of materials and services to support facility operation and irradiation testing.
- Preoperational checkout in preparation for full power operation.

Developmental Plant Conceptual Design Study (CDS)

The CDS, a key element in developing LMFBR options for the future, is a government funded and managed effort to develop the conceptual design of a developmental plant incorporating input and experience from industry and the utilities. The developmental plant design is being conducted to define the next logical step in LMFBR plant development if it is determined that such a step should be taken. The study is based on evaluations and optimization of overall plant safety, environmental acceptability, proliferation resistance, economics, and reliability, and will provide information that can be utilized to guide base program development efforts.

The CDS is being conducted in two phases. The first phase, initiated in October 1978, consisted of:

- Trade-off studies of basic plant design alternatives (e.g., pool vs. loop configuration for the primary heat transport system, steam cycle characteristics, etc.).
- Identification of system design improvements and simplifications.
- Development of safety and licensing criteria.
- Specification of system requirements for major components.
- Identification of preliminary R&D requirements.
- Compilation of summary principal plant design requirements and criteria.

The second phase, which is currently underway, consists of plant conceptual design efforts based on the design selections from Phase 1. The study results will be documented in March 1981. This report will include:

- Description of the developmental plant conceptual design.
- Estimated costs and schedule for design and construction of the developmental plant.

- A description of required R&D to support the developmental plant.

Breeder Technology

Breeder technology development will emphasize long-lead critical technical problems and will provide a basis for future decisions regarding demonstration and deployment of the LMFBR option. Program subelements include: safety; components, materials and structures; physics; and fuels and core materials.

In FY 1981, safety activities will provide the necessary analytical modeling, computer codes and experiments to support the safe operation of the FFTF. Fuel pin transient tests in the TREAT reactor will also be performed.

The effort on components, materials, and structures will continue to encompass the development of major components of LMFBR heat transport systems and auxiliary systems as well as the development of data, processes, instrumentation and control, and analytical methods needed to support component and system design, fabrication and operation. The effort will be directed toward testing available CRBRP components, and toward high temperature design analysis and techniques.

The physics program will utilize the ZPPR at ANL to provide experimental studies on LMFBR core designs of greatest interest in the U.S. program. Such studies will provide valuable confirmation of the accuracy in design methods as well as data of direct application to ongoing reactor design studies. The current base of nuclear data and computational programs will be maintained as required to support the FFTF operations and core reloads. The dosimetry measurements during startup and early operation of FFTF will also be analyzed for application to ongoing fuel [illegible]

The fuel and core materials effort will identify and develop breeder reactor fuel, blanket and absorber elements, and demonstrate their performance capabilities under steady-state and design-transient conditions. It includes the development of fuel fabrication equipment and processes as well as analytical design and performance models, and verifies the models by irradiation testing.

In FY 1981, efforts will continue to determine and improve the lifetime of FFTF replaceable core components such as fuel and absorber assemblies, and to provide fuel fabrication capabilities for continuing operation of FFTF.

Test Facilities

Test facilities are an essential part of the LMFBR program in that they provide the capability to test component designs developed under the breeder technology program as well as prototypes of components to be incorporated into plant projects. This activity also encompasses security and safeguards efforts and landlord functions at several sites.

In FY 1981 the facility modification to increase in flow test capability of the Sodium Pump Test Facility (SPTF) at the Energy Technology Engineering Center (ETEC) from 20,000 to 40,000 gpm (Phase A of Project 78-6-e) will be continued. Modifications to the Small Components Test Loop (SCTL) control room and electrical room will be completed, and construction of the Fuel Storage Facility and the Maintenance and Storage Facility at the Hanford Engineering Development Laboratory (HEDL) will be completed and operation begun.

Construction will continue on the Fuels and Materials Examination Facility (FMEF) which will provide fuel fabrication development and post-irradiation examination capability to be completed in FY 1983. Testing at ETEC will include sodium water leak tests related to steam generators and tests of fuel handling mechanisms and other small reactor components.

The test facilities element also includes a program assurance activity, which supports continuing operation of the Nuclear Quality Assurance Program Office at HEDL, the Nuclear Standards Office at ORNL, and Safety Assessment Offices at ANL and HEDL. The element also supports facility fire inspections, International Nuclear Fuel Cycle Evaluation coordination, and information transfer and assessment activities.

In FY 1981, nuclear materials safeguard systems will be improved at Argonne National Laboratory (ANL), the Hanford Engineering Development Laboratory (HEDL) and the Idaho National Engineering Laboratory (INEL); landlord support will be provided at these three sites and at the Energy Technology Engineering Center (ETEC). The landlord activities include providing various general site services; providing general purpose equipment (GPE); constructing general plant projects (GPP) and line item construction projects for general purpose facilities and certain other multi-program projects; and preventing deterioration of site support facilities, systems, and equipment.

Clinch River Breeder Reactor Plant (CRBRP) Project

The Administration proposes that the Clinch River Breeder Reactor Plant (CRBRP) project be terminated, except for selected design and component activities of value to the LMFBR program. Our current estimate indicates that if termination activities were started by mid-year, funds already appropriated for CRBRP would be sufficient to cover all termination expenses, not including settlement with the utility organizations who are partners in the project, if this should become necessary.

WATER COOLED BREEDER PROGRAM

The FY 1981 Water Cooled Breeder budget request is $61.0 million. This is a $1.0 million increase from the FY 1980 authorized amount. The minor increase is due to anticipated escalation and increased effort in the Advanced Water Breeder Applications program partially offset by a reduction in the level of procurement of LWBR end-of-life program equipment.

The Water Cooled Breeder program's mission is to develop technology for significantly improving nuclear fuel resource utilization by water cooled nuclear reactors used for electrical power generation. The concept currently under development is a self-sustaining breeder reactor cooled and moderated with ordinary (light) water and fueled with uranium-233 and thorium. Successful development of this breeder cycle will provide the basic technology which would make available for power production about fifty percent of the energy in the nation's thorium reserves, a source of energy many times greater than known fossil fuel reserves. The technology is presently being demonstrated by operating a Light Water Breeder Reactor in the DOE owned reactor at Shippingport, Pennsylvania. The LWBR concept is the only known approach using the proven technology of light water reactor systems for increasing fuel utilization efficiency significantly beyond the approximately one percent achievable with present types of light water reactors. The programs within the Water Cooled Breeder program are the Shippingport Atomic Power Station, the Light Water Breeder Reactor, and the Advanced Water Breeder Applications.

The Water Cooled Breeder program is carried out primarily at two Government-owned laboratories: Bettis Atomic Power Laboratory, located in Pittsburgh, Pennsylvania; and Knolls Atomic Power

Laboratory in Schenectady, New York. These laboratories are operated for the Division of Naval Reactors by Westinghouse Electric Corporation and General Electric Company, respectively. The Bettis Laboratory also manages the DOE's Expended Core Facility (ECF) in Idaho, where the spent Shippingport LWBR core will be examined after it is removed from the Shippingport reactor. This examination at ECF will include a nondestructive proof-of-breeding determination. The Duquesne Light Company operates the Shippingport Atomic Power Station.

Shippingport Atomic Power Station (PWR)

The Shippingport Atomic Power Station program's objective continues to be advancing pressurized water reactor technology through testing of advanced reactor concepts. The experience gained from operating the Shippingport Atomic Power Station has provided the basis for much of the technology leading to present central station light water nuclear power plants. Extension of this program has led to the development of the Light Water Breeder Reactor (LWBR), a self-sustaining breeder reactor cooled and moderated with ordinary light water and fueled with uranium-233 and thorium. Since startup, the LWBR core has operated successfully, in both sustained operation at high power and periodic swing-load operations. December 2, 1979 marked the second anniversary of the release of the LWBR core for routine operation to supply power to the Duquesne Light Company distribution system. Currently the core has accummulated more than 14,000 effective full power hours of operation and is continuing to provide valuable data.

The FY 1981 requested funds of $11.0 million will provide for the maintenance and periodic testing of the plant as well as testing and analysis of the instrumented LWBR core. Assessment and disposal of PWR-2 components will continue including preparations for shipping the PWR-2 core barrel.

Following shipment of the LWBR spent core to the Expended Core Facility in Idaho, the Shippingport Atomic Power Station will be turned over to the DOE Office of Waste Management for disposition. This disposition work is not budgeted under the Water Cooled Breeder program.

Light Water Breeder Reactor (LWBR)

The LWBR program's objective is to accomplish three things: prove that breeding can be achieved in a light water nuclear power plant using a thorium/uranium-233 fuel system; confirm a practical way to use thorium, a plentiful source of fuel for which there has been no major energy-related use; and show that it is feasible to install breeder cores in pressurized water reactor plants using the same types of components and systems as are in existing plants.

After another two to three years of power operation, the LWBR core modules will be removed from the Shippingport reactor vessel and the spent fuel will be shipped to the Naval Reactors Expended Core Facility for a detailed core examination to verify core performance including breeding characteristics. If this examination confirms that the LWBR core has operated satisfactorily and bred as predicted, the basic reactor technology will have been established that could make available for power production about fifty percent of the energy potentially available in thorium reserves.

The FY 1981 requested funds of $29.0 million will be used to provide technical support for operation of the LWBR core. This will include establishing whether the reactor can perform satisfactorily beyond the previously identified end-of-life to maximize energy output and conducting periodic tests to evaluate and compare actual performance with physics and thermal/hydraulic predictions. Preparations in support of the LWBR end-of-life effort, which includes fuel removal and disassembly at Shippingport, shipping and module receipt, unloading, disassembly, and examinations at the Expended Core Facility which will be accomplished in future years.

After the detailed spent fuel examination, the spent fuel will be turned over to the DOE Office of Nuclear Materials Production under the Assistant Secretary for Defense Programs for storage and possible later reprocessing. Chemical analysis support for proof-of-breeding effort is being provided by Argonne National Laboratory and is budgeted separately.

Advanced Water Breeder Applications (AWBA)

The FY 1981 funding request for the AWBA program is $19.8 million. The objective of the AWBA program is to develop and disseminate technical information to assist U.S. industry in evaluating LWBR technology and deciding if, when, and how it can be applied to their own programs. Additional development work is necessary to allow U.S. industry to decide the degree to which they want to adapt LWBR technology. The focus of the AWBA program is on exploring technical problems through analytical and experimental work, and developing and disseminating technical information through published technical reports.

The primary emphasis within the AWBA program is on the design and development of improved methods for producing U-233 in water-cooled prebreeders and improving breeding in water-cooled breeder reactors. Areas requiring further development for the uranium-233/thorium fuel systems include: reactor design concepts; general development, such as reactor mechanical design and fuel element design; and fuel fabrication process technology. Irradiation test programs will also be conducted in support of the AWBA program.

The FY 1981 funding request of $19.8 million will provide for: developing improved analysis methods to carry out physics, fuel element, and thermal/hydraulic performance evaluations; conceptual design of an advanced breeder control assembly; continuing development of a close-spaced, triangular pitch, zircaloy grid, fuel rod support system; and testing of a prebreeder bundle in the irradiation test program.

Reprocessing and remote fabrication work which would be required to use the light water breeder concept is not included under the Water Cooled Breeder Program. Such work is the responsibility of the DOE Division of Nuclear Power Development.

Plant and Capital Equipment Funds

Capital equipment funds of $1.2 million are requested in FY 1981 to support continued operation of the Shippingport Atomic Power Station and research and development efforts in the LWBR and AWBA programs. These programs require equipment to support LWBR end-of-life effort, the development of prebreeder conceptual designs, and the development of improved breeding technology aimed at improving fuel utilization. This includes defueling and shipping, core examination, proof-of-breeding, process development, irradiation test support, and fuel development tests.

There are no new major construction projects to be started under this program during FY 1981.

GAS COOLED BREEDER REACTOR PROGRAM

No funds for the Gas Cooled Fast Reactor Program are included in our funding request for FY 1981. The current status of the U.S. and worldwide LMFBR technology indicates that there is no longer a need for a backup breeder to the LMFBR. If there were insurmountable technical problems with the LMFBR they would have been evident by now as the result of extensive actual reactor operating experience over the past 30 years. Furthermore, the recently completed NASAP studies have not shown any nonproliferation advantage of the GCFR over the LMFBR and these studies estimated the total RD&D costs to be several billions of dollars. Consequently, DOE support of GCFR has not been included in the FY 1981 budget and it is proposed to bring the program to an orderly conclusion starting in FY 1980.

FUEL CYCLE R&D PROGRAM

Consistent with the current policy of deferred deployment of the breeder reactor and associated fuel reprocessing, the Fuel Cycle R&D Program is being directed toward maintaining a base reprocessing technology effort with deferral of activities associated with an ultimate engineering scale hot demonstration of fast breeder fuel reprocessing.

The Integrated Equipment Test (IET) facility will be completed in FY 1981. The Remote Operation and Maintenance Development (ROMD) and Integrated Process Development (IPD) sections of the facility will be secured after completion in FY 1981. The component development section, which has been in service for several years, will continue to be used to test first generation equipment components already in place.

The conceptual design of an engineering scale Hot Experimental Facility (HEF), to provide the ultimate demonstration of the reprocessing of fast breeder fuels on a reasonable scale, will be concluded in FY 1980.

The work in FY 1981 will center on base engineering technology development. Work will include the development of remote maintenance modules and testing in connection with remote manipulator development. Seals for the voloxidizer will be investigated in the seal test facility and on the full-scale experimental voloxidizer, which is in place in the component test area. Special problems associated with rotating seals, dealing with effective leak rate through the seals, seal lifetime and maintenance and replacement, will be addressed in the base technology program along with basic work on engineering parameters of the system including the mechanism of heat transport.

Shear development will proceed to a limited extent with the model currently installed. The determination of fundamental engineering parameters will proceed to some extent on the current model of the rotary dissolver including solids heating and transport.

Advanced Nonproliferation Reprocessing Technology (ANRT), which was transferred from the Advanced Reactor Systems programs, will concentrate on the testing of the specific equipment items which were requested in the FY 1980 ANRT supplemental.

A developmental model of a robotized process steam sampler will be tested and further developed for in-cell remote sampling.

Advanced instrumentation concepts used in connection with process control instrumentation will be investigated for potential application to incorporate surveillance of diversion-attempt information and passive use-denial actions.

LWBR-Proof-of-Breeding (POB)

The LWBR-POB analytical support project provides analytical chemistry support to the Water Cooled Breeder (WCB) program. This activity will contribute to the determination of fuel breeding in the Shippingport reactor by calibrating an Irradiated Fuel Assay Gauge (IFAG).

The objective of this program is to destructively analyze select fuel segments which will provide precision analytical chemical data on the fissile content of a limited number of experimental fuel rods irradiated in the Shippingport reactor. These data will be used to calibrate their nondestructive IFAG which will, in turn, permit the determination of the amount of fissile material (uranium-233) bred in the reactor. Fuel is scheduled to be discharged from the Shippingport reactor early in CY 1982 and subsequent chemical analysis is to be conducted by Argonne National Laboratory in CY 1983 and CY 1984. The POB project is scheduled for completion in FY 1985.

ADVANCED NUCLEAR SYSTEMS

The Advanced Nuclear Systems activity is composed of two major program elements: Space and Terrestrial Applications and Advanced Systems Evaluation. The budget request for this activity for FY 1981 is $44 million in budget authority, compared to $39 million in FY 1980.

SPACE AND TERRESTRIAL APPLICATIONS

The DOE Space and Terrestrial Applications activity under the Advanced Nuclear Systems Program is responsible for the development of compact nuclear power systems for use in the exploration of space and for the exploitation of these technologies to support other Government space and terrestrial applications requirements. In FY 1981, this effort will focus primarily on activities in support of the NASA Galileo mission to Jupiter and the International Solar Polar mission. The Terrestrial Isotope Applications effort will continue to examine the use of radiation for the disinfection of dried sewage solids. To date, the sludge treatment program has demonstrated that the use of cesium-137 radiation permits safe and efficient recycle of the nutrients found in sludge products. The program for beneficial use of reactor by-products is supportive of the national emphasis on resource conservation and environmental protection.

Flight Systems Development

In FY 1981, two major flight hardware development programs, which were initiated in FY 1978 and FY 1979 to support the respective mission requirements for the NASA Galileo and Solar Polar applications, will have made considerable progress. The flight acceptance tests on four flight radioisotope thermoelectric generators (RTGs) for the Galileo mission will be completed, and the RTG units are planned to be shipped to the Kennedy Space Flight Center (KSC). The silicon germanium (Si-Ge) unicouple production line readiness in support of the Solar Polar mission will be demonstrated early in FY 1981, and the qualification tests of the flight RTG for that mission will begin.

Isotope Fuels

The isotope fuels program includes the production of encapsulated plutonium-238 fuel forms at the Savannah River Plant, and heat source assembly, generator fueling and qualifications/acceptance testing at the Mound Facility. The Galileo spacecraft power units will utilize the Multi-Hundred Watt heat source. The first

Multi-Hundred Watt (MHW) heat sources fabricated at the Mound Facility are planned to be delivered to the system contractor (GE) for the Galileo program in FY 1980. The remaining three units are planned to be delivered during FY 1981. Plutonium-238 fuel-form production at the Savannah River Plant is directed toward providing encapsulated fuel for a General Purpose Heat Source (GPHS) to be used on the International Solar Polar (ISP) Program. This first ISP generator is planned to be fueled in FY 1981 at the Mound Facility, and qualification testing of the generator will be initiated in the newly completed RTG assembly and test facility.

Power System Technology and Support

The Power System Technology and Support Program element includes developmental activities associated with the advanced space reactor, the essential independent quality assurance and quality control support activities for the flight programs, and a limited program in thermoelectric energy conversion technology. An independent technical assessment of the flight systems contractor activities will be conducted. Quality assurance and quality control activities will be implemented onsite at the contractor's plants by an independent laboratory.

Space Nuclear Reactor--The continuation of the Space Reactor Technology Program is planned in accordance with DOD requests to maintain a space reactor technology effort. This program will permit DOD to have the option to utilize reactor systems in space with reasonable lead times and at acceptable costs.

In this third year of a five-year program to establish the technology base for the development of a 10 KW(e) to 100 KW(e) space reactor, critical analytical and experimental data will be obtained on the heat transfer and metallurgical characteristics of the proposed fuel elements, heat pipes, and thermoelectric materials. The selection of materials for further component development will be made based on this data. Experience will be gained in the fabrication of fuel elements and full-scale heat pipes. In addition, component testing will be pursued on fuel element modules, heat pipes, thermoelectric modules, radiator modules, control system actuators, and temperature sensors.

Dynamic Isotope Power Systems--To support DOD space power options in the 1-2 KW(e) power range, a Dynamic Isotope Power System Program was initiated in FY 1976. Phase I was completed in June 1978 with the Organic Rankine Cycle being selected for flight development. The technology verification program of the 1-2 KW(e) Dynamic Isotope Power System (DIPS) is scheduled to be completed in FY 1980.

The successful completion of the DOE technology verification program is planned to minimize both the technical risk and flight development schedule in support of a DOD flight commitment. No additional DOE support is planned for this effort and any future development of the dynamic system beyond the technology verification program will be conducted on a reimbursable basis.

Space Power System Safety

This effort will provide for a detailed safety review of the Galileo mission, including the risk assessment required for flight approval. In FY 1981 the safety environmental testing and analyses of the Multi-Hundred Watt (MHW) generator components for use in the Galileo mission will be conducted. Plutonium-238 fuel sphere assembly tests will be completed as part of the safety verification series. Also, in FY 1981, the Final Safety Analysis Reports (FSAR) for the Galileo mission will be reviewed by the

Interagency Nuclear Safety Review Panel (INSRP). The Updated Safety Analysis Report for the Solar Polar mission will be completed and reviewed by the INSRP, and the safety verification tests and analyses for the Solar Polar plutonium-238 heat sources will be completed. This effort also provides for the ongoing research efforts in space nuclear technology.

Terrestrial Isotope Applications

The Terrestrial Isotope Applications Program includes: (1) continuing operation of the Sandia Irradiator for Dried Sewage Solids which became operational in FY 1979; and (2) further research at Oak Ridge National Laboratory relative to the effects of cesium-137 gamma radiation levels on a variety of pathogens found in sewage sludge. Recent regulations issued by the Environmental Protection Agency recognize a dose of one megarad of gamma irradiation as being adequate to reduce the pathogen content of dried sewage solids to a level permitting sludge application to croplands as a soil conditioner or a fertilizer without any significant delay. Animal feeding and agronomy studies will be continued to assess this new option for recycling of the nutrients found in sludge.

Technology transfer liaison will continue with city and state governments as well as Federal agencies, such as EPA, USDA, and FDA, to keep them informed of the progress being made and to determine the validity of this process in solving site specific sewage sludge disposal problems. These technology development and pilot operations are being conducted under joint DOE and EPA support. Agricultural and animal supplemental feeding experiments using the disinfected sludge are being carried out at New Mexico State University.

As energy conservation becomes more and more important, cesium-137 and other radioisotopes can play an increasingly significant role as energy sources in specialized applications.

ADVANCED SYSTEMS EVALUATIONS

The Advanced Systems Evaluations activity, under the Advanced Nuclear Systems Program, is directed toward the evaluation, development, and deployment of conventional, advanced, and specialized nuclear systems for various applications. Two major activities are 1) improving the utilization of the thermal energy produced by nuclear power plants, and 2) increasing the siting acceptability of nuclear systems.

The improved thermal utilization effort includes the study of cogeneration for the concurrent production of electricity and thermal energy for district heating or for industrial processing and the evaluation of various methods of using power plant waste heat for beneficial purposes such as agriculture or aquaculture.

Efforts to increase the siting acceptability of nuclear systems include: 1) the study of nuclear energy centers, 2) advanced power plant cooling methods to reduce water consumption, and 3) a determination of the meteorological effects of moisture and heat releases from power plants. Some of the efforts involve joint studies with states, localities, industry, and industrial organizations (e.g., EPRI).

A cogeneration district heating system demonstration is being assessed for the city of St. Paul, through a joint effort with DOE, the city of St. Paul, the Minnesota Energy Agency, and Northern States Power. Cogeneration for district heating increases the thermal utilization of a power plant from 35 percent, when only electricity is produced, to about 85 percent when electricity and hot water are produced for district heating.

The city government envisions that construction of a cogeneration/ district heating system in the central portion of the city could begin in 1981 and be completed in 1985. The system would be the first phase of a regional system that could save the equivalent of three million barrels of oil per year.

Clustering of nuclear power plants in energy centers is receiving more attention through jointly funded programs with states and localities due to the possibility of siting nuclear units farther from populated areas and decreasing the number of reactor sites. An energy center feasibility study at a site in South Carolina will be completed in FY 1980, and a study of a similar site in Utah in FY 1981.

A computerized Water Use Information System has been developed jointly with the U.S. Geological Survey whereby water availability, power plant water usage, projected energy growth, and laws and regulations concerning such uses are stored for over 2000 subregions in the United States. In FY 1981 the information system will be upgraded and the predictive model used to determine water deficiencies in selected regions of the United States.

COMMERCIAL NUCLEAR WASTE

I would now like to discuss DOE's Commercial Nuclear Waste Program. The budget request for this program for FY 1981 is $299 million in budget authority, compared to $220 million in FY 1980.

DOE has the responsibility for the disposal of waste from civilian uses of nuclear power. This final disposal must provide isolation of these wastes from the human environment for as long as they remain hazardous. The Commercial Nuclear Waste Program objective is, therefore, to provide facilities for terminal isolation and to develop the technology necessary to provide for the disposal of radioactive wastes produced in the civilian sector primarily from the production of electricity.

The Administration policy with regard to nuclear waste will continue to be based on the protection of public health and safety now and in the future. The program that I will describe today incorporates recommendations made concerning the content of the technology program in the final report issued by the Interagency Review Group (IRG) on Waste Management, and decisions announced by the President in his recent policy statement on radioactive waste management.

COMMERCIAL WASTE MANAGEMENT

This activity includes Terminal Isolation, Waste Systems Evaluation and Public Interaction, and Waste Treatment Technology. The budget request for FY 1981 is $245 million, as compared to $185 million in 1980.

Terminal Isolation

As you know, the IRG has recommended that disposal facilities for radioactive waste should be in deep geologic formations if suitable sites can be found. A draft Generic Environmental Impact Statement (GEIS) was issued in 1979 which evaluates and compares the environmental impacts of ten alternative disposal techniques. The evaluation supports a continued emphasis on deep geologic disposal. As a potential backup, sub-seabed disposal investigations will be funded at a level sufficient to provide a technical and environmental feasibility report by the end of 1983.

Deep geologic disposal, then, is being pursued as the interim strategic planning basis. Under the terminal isolation program the necessary research and development to identify sites for repositories and to develop technology necessary for the design, licensing, and operation of a geologic repository will be conducted. The repository will be designed to accept commercial spent fuel, solidified high-level waste including defense waste, and transuranic wastes.

As a result of the IRG recommendations, the President has decided to delay selection of the initial disposal site until several alternative sites have been fully investigated and compared. Detailed studies of specific, potential repository sites will be continued in several geologic environments with additional emphasis on rock media other than salt. The program will develop a number of fully-characterized sites from which one or more can be chosen as repositories for spent fuel, transuranic and other high-level (e.g., defense) waste.

The Administration has decided that the Waste Isolation Pilot Plant (WIPP) Project near Carlsbad, New Mexico, should be cancelled and that transuranic defense wastes previously intended for disposal at WIPP should be placed instead in the first commercial waste repository. The Carlsbad site should continue to be investigated and set aside as one of the possible alternative sites for the repository. Depending on the exact timing of site selection, it is anticipated that the first commercial repository could be operational in the mid-1990's.

The site characterization effort will include studies of salt formations including salt domes and bedded salt. The interior Gulf Coast domes (Mississippi, Louisiana, and Texas) are of interest, as are portions of the Permian (Texas), Paradox (Utah) and Salina (Michigan, Ohio, and New York) bedded salt basins. An expansion of this activity into several new states to explore potential sites in non-salt geologies is now underway and this activity will increase in FY 1981. Program strategy is to proceed with a three-stage process of regional, area, and site specific investigations; each stage narrows the focus and increases the depth of information about each location to the point where specific sites can be chosen or rejected.

We are also continuing our evaluation of the potential of deep basalt flows below the Hanford reservation in the State of Washington and the suitability of the Nevada Test Site (NTS) in southern Nevada which has been used in the past for testing of nuclear weapons. In FY 1981 geohydrologic investigation of candidate areas at both sites will be conducted.

The program calls for identification of several candidate sites in salt domes and basalt during FY 1980 with final recommendations in 1981. Candidate sites in other salt and non-salt formations could be identified three or four years later.

In the area of technology development, work continues in both broad, long-term generic and media-specific areas. In FY 1981, these activities include the evaluation of alternative engineered barrier concepts, laboratory and field testing of borehole plugging concepts, spent fuel packaging studies at the Engine-Maintenance Assembly/Disassembly (E-MAD) facility at NTS, and radionuclide transport studies and risk assessment modeling in various media.

In-situ geologic media tests will continue in FY 1981 to provide valuable data for repository development and design. In-situ thermal tests using electrical heaters will continue in salt at Avery Island, Louisiana, in granite at Stripa, Sweden, and in basalt at the Near Surface Test Facility (NSTF) at Hanford. Construction will be completed in FY 1981 at NSTF for a demonstration test involving encapsulated spent fuel and high-level waste. Operation of the Climax Spent Fuel Test Facility to determine the behavior of granite with spent fuel will continue in FY 1981. Also, preparation for radioactive in-situ tests at a Salt Test Facility will be in progress. We want to emphasize that none of the locations for these tests involving radioactive material are considered as a permanent disposal location.

Efforts will also continue in FY 1981 in support of facility design and development. Work will emphasize design optimization studies for a repository in dome salt and conceptual design studies on alternative geologic media, such as basalt.

Waste Systems Evaluation and Public Interaction

This activity provides for State participation in planning and implementation of the site qualification and selection program for a commercial waste repository. With State assistance, the commercial repository program as well as other aspects of the Commercial Nuclear Waste program can be tailored to embrace essential provisions as necessary for political and public support. The Interagency Review Group (IRG) determined that State and local government participation is essential to successful repository siting and recommended that a State Planning Council (SPC) be established. The President is establishing this Council through an Executive Order. Through this council, and other avenues, a process of "consultation and concurrence" with States involved in waste management siting studies will be conducted. In addition, States would be provided with funding to allow for independent State assessments of the Federal program. The SPC, will be established in FY 1980. About 15 States could have sufficient program activity in FY 1981 to require overview funding.

This activity also includes funds for support in the areas of quality assurance; independent assessment and evaluation of the feasibility, economics, and safety of alternative waste management systems; and maintenance of a program for integrating and supporting the international nuclear waste management activities concerned with bilateral and multinational information exchanges and cooperative R&D programs.

The FY 1981 efforts will include: quality assurance assistance to nuclear waste management programs in the form of personnel training, recommendation of appropriate methods and procedures, preparation of documentation, implementations of standards, and the conduct of audits; waste management systems studies to provide cost estimates, technical assessments, and analysis of public attitudes and issues for use in the comparison of alternatives; continued efforts toward the development of improved methodology for nuclear waste management system safety assessments; preparation of updates of the "International Waste Management Source Book"; and continued review of waste management programs and projects by the National Academy of Sciences' Committee on Radioactive Waste Management.

Waste Treatment Technology

The objective of this program is the development of technology for immobilizing waste from nuclear fuel cycles and converting it to forms which provide safety and economy of management, satisfy regulatory requirements, and are acceptable for disposal. Processes deal with a variety of wastes: high-level and low-level liquids, low-level solids, TRU contaminated solids, and gases. Each of these waste types requires processes that reduce the volume and/or convert the materials into stable, less dispersable forms for safe transport and/or long-term isolation.

Waste forms which are to be placed in a geologic environment provide one of many barriers to the release of radioactivity to the environment. The immobilized waste forms will be designed to retain their integrity until the more troublesome radioisotopes decay in the geochemical environment of the host rock.

For high-level waste, implementation of the Materials Characterization Center will permit confirmation of the properties of a variety of alternative waste forms in addition to borosilicate glass. In FY 1981, techniques under development for the treatment of transuranic contaminated wastes will be documented and made available to industry.

Development of low-level waste treatment technology will continue in FY 1981, leading to the completion of a demonstration program in FY 1985. The development of promising alternatives to shallow land burial will also continue in FY 1981. We will collect low-level waste data on a State-by-State basis, assist the States in developing plans for their wastes, and conduct joint technology demonstrations and other activities to complement or support State initiatives in the management of commercially generated low-level waste.

The FY 1980 Appropriations Act directed DOE to provide necessary technical support to study and recommend a nuclear waste solidification program at West Valley, New York, for the liquid high-level waste located there. We have initiated that program. Activities include preparation of an Environmental Impact Statement, a waste characterization program, preconceptual design of a solidification process, a program to remove the waste from the tanks, and a development program to support a selection of a waste solidification process system.

REMEDIAL ACTIONS

The DOE Remedial Actions Program, which is a newly assigned activity in the Commercial Nuclear Waste Program, involves the integration of four programs previously conducted under the Assistant Secretary for Environment (ASEV). The budget request for this program for FY 1981 is $54 million in budget authority, compared to $35 million in FY 1980. It should be noted that this includes $5 million for a proposed R&D demonstration of solidification of West Valley wastes. Remedial actions include: decontaminating formerly utilized sites of the Manhattan Engineering District (MED) and AEC; implementing of remedial actions at the 25 designated mill tailings locations that were authorized by Congress under P.L. 95-604, the Uranium Mill Tailings Radiation Control Act of 1978; continuing remedial actions to remove tailings from about 800 residences, businesses and public buildings at Grand Junction, Colorado; and decontamination and decommissioning programs for DOE-owned surplus research, test, and development facilities that were part of the nuclear development programs of the Department and its predecessor agencies. This latter element also includes the development and documentation of decontamination and decommissioning technology for transfer to the commercial nuclear industry.

The Formerly Utilized Sites Remedial Action Program (FUSRAP) consists of projects of remedial action at former AEC/MED-owned or contractor sites and adjacent contaminated properties that have been determined by the ASEV as requiring remedial action to eliminate radiological contamination that may restrict the use of the site. To date, surveys have identified about 30 sites that will potentially require remedial action. About 17 sites have been documented sufficiently by the ASEV to identify them as remedial action projects. No legal authority exists for the Department to undertake some of these projects. At other sites, authority needs clarification. We are therefore preparing to introduce legislation to the Congress in this session to authorize the required remedial action at such sites, and to authorize the acquisition of disposal sites in consultation with affected States. As more sites are confirmed with respect to the scope and priority of remedial action, they would be added to the program as part of the annual authorization.

We conducted remedial action in FY 1979 at one site near Jersey City, New Jersey, to allow commercial development to proceed on a portion of a former site of the Kellex Corporation that conducted research for the AEC. In FY 1980 we are beginning a major decontamination effort at a number of private properties in Middlesex, New Jersey. Our efforts will expand in FY 1981 to progressively plan, organize and implement remedial action projects at high priority sites as determined in conjunction with the ASEV and consistent with current authorization. After the sites are decontaminated, the conditions would be independently certified by the ASEV.

It is anticipated that the uranium mill tailings program will increase in activity in FY 1981. This assumes that the EPA criteria for this program, which must be issued before we can prepare firm specifications, obtain reliable estimates, prepare

NEPA documentation, or perform any remedial action, will be promulgated by the end of FY 1980. Our activities in FY 1980 and 1981 will concentrate on high priority sites most impacting the public exposure - Salt Lake City, Utah; Durango, Colorado; Canonsburg, Pennsylvania; and Shiprock, New Mexico. During FY 1981 we expect to complete the environmental documentation and the detailed engineering for these sites and to initiate remedial action at one or more of them. Remedial action consists of removing the tailings to an alternative location where they can be stabilized on property owned by the Federal government and away from populous communities. Other sites will be stabilized in place and the property acquired by the Federal government. In FY 1981 we will continue R&D on removal and stabilization technology and preparatory work on the remaining high priority sites.

The program at Grand Junction is proceeding and is now estimated to be completed in FY 1985. The total number of sites is now estimated to be about 800. This figure is regarded as fairly firm as we are approaching the June 1980 cut-off date for eligibility under this program. The estimated final cost of this program is now approximately $23 million. The State of Colorado has conducted the program efficiently and has shared 25 percent of the cost. Additional Federal authorization of $7.5 million will be required to cover the completion of this program in FY 1981. This authorization is being requested under a separate title of the proposed FUSRAP legislation. If the criteria promulgated by EPA for the mill tailings program are more stringent than those in use at Grand Junction, more sites may become eligible under the Uranium Mill Tailings Remedial Actions Program.

The program to manage and dispose of surplus DOE facilities now includes the reactor, laboratory, test and processing facilities that were determined to be surplus in October 1976, as well as facilities that have subsequently been determined to be surplus to current needs. The program covers the surveillance and maintenance of surplus facilities pending their disposition as well as the planning and implementing of projects to progressively eliminate the inventory of facilities and sites that must be managed. Included are the former New Brunswick Laboratory at New Brunswick, New Jersey; the former Lake Ontario Ordnance Works site at Niagara Falls, New York; and other laboratory and test facilities. In FY 1981 the program will provide for engineering planning to decommission the Shippingport Atomic Power Plant near Pittsburgh. This project will provide definitive technology and data on costs and radiological exposure which will be of use to the commercial nuclear industry.

SPENT NUCLEAR FUEL

Now I will discuss the Spent Nuclear Fuel Program. The budget request for this program for FY 1981 is $21 million in budget authority, compared to $18 million in FY 1980.

The DOE Spent Nuclear Fuel Program supports the Administration's policy objective of ensuring that spent fuel is stored at reactor sites to the greatest extent possible. As outlined in the President's recent waste management policy statement, the Administration believes that a limited amount of government away-from-reactor (AFR) storage should be provided for those utilities that are unable to find other storage; however, commercial utilities will continue to bear the primary responsibility for the storage of spent fuel. In addition, the spent fuel program supports U.S. nonproliferation objectives.

As you know, the Department and the Administration have submitted a legislative proposal which would authorize the Secretary to accept and take title to commercial spent fuel and to acquire facilities for the storage of that spent fuel in AFR storage facilities.

DOE is preparing for release an updated report on storage requirements. This data reconfirms the immediate need for AFR storage for U.S. fuel. Six reactors are currently operating without full core reserve capability. DOE firmly believes that full core reserve capability is an important operational flexibility and economic asset.

Based upon utility plans as of June 1979, the requirement for AFR capacity will increase to between 240 metric tonnes (with transshipment) and 620 metric tonnes (without transshipment) by 1983. These requirements assume NRC approval of utility reracking plans beyond those currently approved. If new reracking approvals are not granted, the AFR requirement for 1983 could increase to 1,140 metric tonnes even with transshipment. If all utilities reracked their basins to the theoretical maximum storage density (which may not be possible due to structural limitations or operating constraints), the AFR requirement in 1983 would still range between 170 metric tonnes (with transshipment) and 380 metric tonnes (without transshipment).

Although DOE believes that transshipment is safe, the regulatory and institutional climate has resulted in delays for the utilities in obtaining approval from NRC. For example, Duke Power has been seeking approval to transship fuel between two of its reactors for almost two years. Although the construction of new pools at all reactors requiring additional storage capacity could eventually reduce this requirement, once these new pools are licensed, built and available, DOE analysis indicates that such individual pools would be inefficient and result in higher cost and greater environmental impact than several AFR's which could meet the needs of all reactors. Also, since a date for the shipment of the spent fuel from the reactor site for either disposal or reprocessing cannot be established at the present time, utilities could not accurately forecast individual reactor storage requirements. Under these circumstances, the utilities' ability to plan for, license and provide a sufficient number of new pools is very doubtful. Therefore, the option of interim storage in Government AFR's is a prudent action and should be provided. With any of these scenarios, the amount of fuel stored in the AFR is a small fraction (less than 5 percent) of the fuel stored at the reactors. We believe that this is appropriate, since utilities should provide storage when it is reasonably possible.

DOE has recently completed a study of reracking, at-reactor (AR) and away-from-reactor (AFR) storage which concluded that reracking by utilities is by far the least expensive ($16/kg unit storage cost) and most preferred approach in increasing storage capacity. If new construction is required, AFR's are less expensive ($130/kg unit storage cost) than new AR basins at one to three 1000 MWe unit sites ($320 to $137/kg unit cost).

Storage needs in 1983 and 1984 could be met only through the acquisition of one or more existing storage facilities. If a new facility were constructed, it would not be available until after 1985. No decision regarding the acquisition of existing storage facilities will be made until a site specific environmental impact statement on storage facilities is completed and costs for acquiring facilities are defined. The final generic environmental impact statements on the spent fuel policy will be issued soon. DOE is currently planning to provide in April the initial report proposed in H.R. 3000 on projected AFR storage requirements and potential storage sites.

The proposed FY 1981 budget assumes that either borrowing authority or revenues from spent fuel charges will be available to cover the acquisition and operating expenses of storage facilities. The funds requested will provide for business activities, licensing and storage research and development. Prelicensing and conceptual design activities started in FY 1980 will continue in FY 1981 to permit prompt implementation of the program to meet near-term storage needs. A business office will establish and collect a charge for storage and disposal services, which will permit full recovery of the government's expenditures.

The principle that will be applied to financing the cost of nuclear waste management and disposal is that the cost should be paid by the generator of the waste and borne by the beneficiary of the activity generating the waste. Utilities will pay the cost of storage and disposal of waste from power plant operations and pass these costs on to their customers. The government will pay the cost of storage and disposal of wastes from defense and government R&D activities and finance it from tax revenues.

During FY 1981, research and development will continue to ensure the safe and efficient operation of storage facilities. Currently, fuel assemblies are stored in water basins both at reactors and away-from-reactors. Fuels of various types will be analyzed to identify their potential for fuel cladding failure. Fuel failure detection and fuel content and criticality monitors will be developed to facilitate operations. The storage of disassembled fuel underwater has the potential for greater storage capacities in the same space. Techniques for disassembling and storing fuel will be developed and demonstrated. Dry storage in caissons or shielded containers will also be further developed and demonstrated at the E-MAD facility at the Nevada Test Site. Analytical data on advanced storage techniques, like dry or disassembled fuel storage, will provide a basis for decisions on the use of these technologies in meeting storage needs between 1985 and 1990. The program will also address transportation problems or shortfalls that could affect the availability of systems to transport spent fuel.

The international spent fuel program will support U.S. nonproliferation initiatives. The dissemination and exchange of technical information is beneficial to both the U.S. and foreign countries. The FY-1981 budget request includes funds for the conduct of feasibility and design studies related to expanding existing foreign storage facilities and establishing new foreign storage facilities which could serve one nation or a group of nations. The program would ensure that countries have the technical information necessary to store fuel so that premature reprocessing due to storage capacity limitations can be avoided.

A clear near term need exists for some AFR storage. If Congress provides DOE with the authority, we plan to provide a limited amount of storage capacity. This cautious approach represents sound management of the Nation's electrical generating capacity and is, at the same time, cost effective. We urge that Congress provide us with the authority and funding to permit us to support this vital part of the U.S. nuclear waste management effort.

This completes my review of the individual program elements. In closing, Mr. Chairman, the major thrust of our nuclear fission program for FY 1981 is to reaffirm the commercial light water reactor by improving the technology and by alleviating or eliminating those concerns that could restrict its utilization. A second thrust is to conduct the necessary research and development activities to ensure that the breeder reactor is a viable option for the supply of future energy requirements. We believe that we have structured a flexible program to meet our near-term requirements while protecting our long-range capabilities. We seek the support of the Congress in implementing this program.

Senator CHURCH. Well, thank you very much, Mr. Secretary. It is my understanding that OMB cut the DOE budget breeder research base program by $200 million before the final budget was submitted to Congress.

Did OMB explain the rationale for that severe a cut?

Mr. CUNNINGHAM. Well, basically, this action was in concert with the administration's estimated need date for the breeder of around 2020 to 2025.

It was concluded that we should maintain a base technology effort, but that this base technology effort should not be scaled up to a level which would support a near term plant project.

So, in effect, the total effort of the program was reduced by about $200 million, and, in fact, the program has been reduced to a base research and development program and support of some of the more important facilities such as the FFTF and the EBR-2 facilities in Idaho.

Senator CHURCH. Would you just repeat the final part of your answer?

Mr. CUNNINGHAM. Yes, sir. I said, basically—in handling the budget reduction of $200 million, we have taken the approach of trying to maintain a balanced program. That balanced program would continue support of our more important facilities. These included facilities such as the Fast Flux Test Facility at Hanford; it includes the EBR-2 reactor in Idaho and includes a number of the other safety and test facilities at various locations around the country.

Senator CHURCH. Well, you will remember that, back in September of 1978, there was an understanding reached with the administration concerning the level that would be maintained for the technology associated with the breeder; also, with respect to moving forward with plans to develop a larger breeder than the one that had been planned for Clinch River.

That agreement has just gone up in smoke, has not it?

Mr. **Cunningham**. Well, I should say, first of all, that we have continued the conceptual design studies for the larger reactor program. Those are still in progress, and we would expect to continue them into next fiscal year with the studies being concluded in the early part of 1981, probably about March or so.

I think the main difference that you are referring to is one in which the administration has made the determination of a need date for a plant to be much later than was proposed in fiscal year 1978 and, therefore, the administration is not proposing any plant construction at all at this time.

Senator **Church**. Well, it was also understood that the breeder reactor technology program would be maintained at a level of about in excess of $500 million and, obviously, that commitment by the administration has been overturned.

The figures show that. You are coming in with a $384 million budget.

Mr. **Cunningham**. Yes, sir. I believe that commitment was made with the understanding that it would be possible to reach some kind of resolution on the Clinch River reactor but unfortunately, we have not been able to reach any resolution on that subject.

Senator **Church**. If we cut back the spending to the $384 million level, what does it do to the community that we have developed of experts in this field? How many specialists are we going to lose?

I should think that a reduction of that kind would have a devastating impact upon the mind power we have to devote to this specialty.

Mr. **Cunningham**. Yes, sir. There is no way to take a cut which is this significant without also affecting the manpower involved.

And in my view, although we have not worked out the complete details yet, we would expect each of our laboratories or facilities participating in the breeder program to suffer some impact.

Some locations would be more severely affected than others. We don't have an exact number yet, but it could be on the order of 2,000 to 3,000 people.

Senator **Church**. I am wondering if you could submit a breakdown and show me where the cuts would be made and how they would affect the program in Idaho.

Mr. **Cunningham**. Yes, sir. We would be pleased to provide that to you. As I indicated, we are still working with the individual laboratories trying to come up with a more detailed answer to that. But we can certainly provide you with the information we have to date.

[The requested information follows:]

FISCAL YEAR 1981 CONGRESSIONAL BUDGET SUBMISSION

[Man-year reduction from fiscal year 1980 October financial plan level]

	Operating									
	Breeder studies	Comp.	Fuels	Mat'ls	Physics	Safety	CRBR	FFTF	Test facility	Grand total
Agbabian				3.4						3.4
Argonne National Lab		[2]185	13	10.6	21	33			30	292.6
Atomics International	0	20	15	3.0	2	7				47
Babcock and Wilcox	0	10								10
Battelle Columbus		0								0
Boeing	0									0
Brookhaven National Lab					5					5
Combustion Engineering			13			0.5				13.5
CRBR							1,580			1,580
Dupont			0							0
EG&G				6.0	3	21			200	230
ETEC/LMEC		2							125	127
General Electric	0	14	76	11.3	5	55				161.3
Hanford Eng. Dev. Lab		3	111	3.4	3	26		130		276.4
Los Alamos Scien. Lab			128		6	9				143
Massachusetts Inst. of Tech.					3					3
National Bureau of Standards					1					1
Naval Research Lab			3	2.2						5.2
Oak Ridge National Lab		1	6	4.7	6	11				28.7
Pacific Northwest Lab		1	16							17
Purduc					4					4
Rensselaer Poly Tech					2					2
Sandia			0							0
Science Applications Inc.						1				1
Stanford Research						3.5				3.5
U.S. NOAA						6.5				6.5
Westinghouse	0	48	125	27.5	3	19				222.5
Total	[1]0	284	506	72.1	64	192.5	1,580	130	355	3,183.6

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[1] Personnel to be funded under breeder technology during latter half of fiscal year 1980.

[2] Reflects loss of 79 personnel at ANL and 106 ANL-subcontract personnel, i.e., 24 at Atomics International, 36 at Byron Jackson, 45 at Westinghouse, and 1 at ETEC.

Senator CHURCH. All right. There is a vote on in the Senate. So, let us take a short recess while I go over to vote; then I will return.

[Whereupon, a brief recess was taken.]

Senator CHURCH. Mr. Secretary, for years now, we have been trying to get an adequate waste treatment program established for the on-line transuranic waste at the INEL in Idaho, all of which are located above the aquifer.

To treat these wastes and to put them in a form suitable for final disposition will require construction of a slagger paralysis incinerator.

At the time you came up for confirmation, you said you would look into that matter. I understand that you now oppose going foward with that project. Why?

Mr. CUNNINGHAM. Well, if I might, I'd like to clarify that, Mr. Chairman. I don't oppose the project, per se.

As I indicated to you, I have looked into the program and reviewed it from a technical standpoint. I am concerned that we don't have a strong enough research and development basis for proceeding with the project now.

On the other hand, I am convinced that we have to do some type of waste treatment preparation of the transuranic waste before it can be placed in a repository.

In my view, it is necessary to continue development work either on a slagger or some type of incinerator, for the purpose of both reducing the volume of the transuranic waste and preparing it for actual placement in a repository.

Senator CHURCH. But there is nothing in the budget to permit the continued planning and design work for such an incinerator, is there?

Mr. CUNNINGHAM. Yes. There is some funding available for continued design work.

The funding which was eliminated was related to the construction project.

Senator CHURCH. Is the money that is available carryover money?

Mr. CUNNINGHAM. Part of the money is carryover money. One of the major technical problems has to do with the treatment of the off-gas.

Now, the treatment of the off-gas to date has been worked on only on a very small scale in the hot cell at Idaho and engineering design studies and experiments.

And I believe that considerably more research, with development and actual design effort is necessary with regard to the off-gas treatment.

I think we can proceed with those parts of the program as part of our regular waste management program.

Senator CHURCH. How much is there in the fiscal year 1981 budget for this R. & D. work described?

Mr. CUNNINGHAM. The total transuranic waste technology effort is $24,582,000 for fiscal year 1981. With regard to the specific amount for the off-gas treatment, I will have to provide that for the record.

Senator CHURCH. Well, how much of the $24,582,000 would be applied to the incinerator and the off-gas problems? What proportion of this total would go into that?

Mr. CUNNINGHAM. Continuation of the slagger effort, itself, is in the operating budget for $5 million.

With regard to the actual amount of money for the off-gas R.&D., I don't have that detail here, but I will provide that for the record.

[The requested information follows:]

It is anticipated that fiscal year 1979 and fiscal year 1980 P.E. & D. carryover funds will be spent on off-gas treatment system design. This work may even be accomplished this fiscal year.

In addition to the $5,000,000 proposed for the slagging pyrolysis incinerator, about $2,500,000 will be spent on incineration and off-gas related work.

Senator CHURCH. Would that be a part of the $5 million or in addition?

Mr. CUNNINGHAM. In addition to the $5 million.

Senator CHURCH. What would the $5 million be used for?

Mr. CUNNINGHAM. Part of it is for the design effort. The majority of it is for the program which we described before you earlier regarding the testing of an incinerator of that type at Reedy Creek, Fla., in the nonnuclear mode.

Senator CHURCH. You may also be aware of the political problems associated with the injection of certain liquid wastes into the aquifer in Idaho.

Mr. CUNNINGHAM. Yes, sir.

Senator CHURCH. The Department has promised to examine alternative ways of dealing with these liquid wastes and to have some recommendations or to complete some studies by October of this year.

Mr. CUNNINGHAM. Yes, sir.

Senator CHURCH. Is that still on schedule?

Mr. CUNNINGHAM. Yes, sir. My understanding is that it is on schedule. I plan to be at Idaho, myself, at the end of May, and I will review the program again at that time.

Senator CHURCH. Recently, the Department agreed to drill some additional wells, from money that was made available for this purpose, to monitor the aquifer and get more information concerning its behavior, the water flow and the extent to which liquid wastes may have contaminated the water.

You are aware of that effort?

Mr. CUNNINGHAM. Yes, sir.

Senator CHURCH. I think that the major problem we have to overcome in the nuclear field is increasingly the problem of public resistance.

I would have to say that, with programs of the kind you keep offering, we will never overcome the problem; it is just going to keep getting worse.

You have now postponed until the end of the century or the beginning of the next century the completion of a permanent repository.

I have no confidence at all that the public would be willing to wait that long. I think public resistance to nuclear power will bring it to a standstill.

Is that really the objective of the administration?

Mr. CUNNINGHAM. No, sir, Mr. Chairman.

Senator CHURCH. I cannot read your figures or your position on any of the major questions relating to the future of nuclear power, the breeders, the processing, any other way but as a clear message that, beneath it all, the end purpose of the administration is to put a stop to nuclear power.

If that is the purpose, you ought to just say it. We could then have it out and decide one way or the other.

This slow strangulation of the program that has been going on is leading, it seems to me, in the direction of complete stoppage somewhere down the line.

That bothers me a great deal.

Mr. CUNNINGHAM. Well, Mr. Chairman, I certainly would have to agree that the breeder program is being delayed, as proposed in the administration's budget.

On the other hand, there have been strong statements ranging from the President on down in terms of supporting the need for nuclear power in the near term.

And we are trying to do a number of things in the technical area to help increase public awareness and public acceptance.

For example, we have instituted a monitoring program in the Three-Mile Island Area where citizens are being taught to use monitors to measure the radiation levels and understand those things, themselves.

We are attempting, in the light water reactor program, to work on improved safety, uranium utilization, and work with industry in those areas associated with the present-day light-water reactors in whatever ways we can to try to provide some leadership and some technical assistance in terms of improving the situation there.

Senator CHURCH. Even if we accepted your premise that the ongoing program is really largely confined to water-cooled reactors, conventional reactors, for what you call the near term, that is all we are going to have if there is no breeder. We are just going to have a program that will end when the uranium supply ends.

The rest of the world is paying no attention to us. They are proceeding full steam ahead with their own breeder technology, and we will be left like the spy out in the cold.

All of the deliberation problems that have concerned the President and the administration are going to develop, anyway. They are, in fact, developing.

As we lose our leadership in this field worldwide, we will have less and less to say about any kind of international control system on proliferation.

The policy, no matter how you look at it, makes no sense for the United States, to lose our leadership, to lose our influence, to lose our technology to other nations. It makes no sense to me.

As far as the conventional reactor is concerned, you are going to lose that, too, because public resistance is growing to that and will.

I don't blame the public. As long as the Government cannot demonstrate that it is ready or willing to deal with the proper processing, treatment, and disposal of waste, why should not public resistance grow?

It is—every year you have more evidence of it—that you have an incapacity to cope with it at DOE, either an incapacity or an unwillingness or you are operating under instructions that do not permit you to cope with it.

I should think that at least the administration would want a waste program, would want to move ahead with the treatment and disposal of waste instead of living in this fairy land of projecting a permanent repository some time in the next century.

I really am baffled.

I take it that you have approved of the $61 million request for the water-cooled breeder program, the Navy program?

Mr. CUNNINGHAM. Yes, sir.

Senator CHURCH. What about the gas-cooled reactor, is that going to be phased out completely?

Mr. CUNNINGHAM. As far as the administration proposal for this year, we have proposed no funding for either the fast gas-cooled reactor or the high temperature gas reactor.

And in both cases, we would propose to phase them out next year.

Senator CHURCH. That figures.

Well, I had lunch about a month ago with a man who knows a lot more about energy than—with all deference to you, gentlemen—at least he knows a lot more about oil than anybody in the Department of Energy, and that was Sheik Yamani, who is probably the most powerful man in the world because he has his hands on that big valve that can turn up or turn down the oil from Saudi Arabia.

He was quite frank to tell us in the Foreign Relations Committee that serious and chronic oil shortages would be developing by 1983 and that, by 1985, we would have to make drastic changes in our way of life in this country because they had no intention of operating at levels that we expected from them or at any level that was contrary to the optimum long-term use of the fields and the optimum development of the oil contained in the fields.

I cannot fault them for taking that view in their own self-interest, but there is nothing in our energy program that is even addressed to such shortages developing so soon. The downgrading of nuclear energy as one of the alternatives just adds to the lack of reality.

Would you summarize DOE's involvement with the West Valley facility to date, please?

Mr. CUNNINGHAM. Yes, sir. As you know, we have had a series of studies going on at West Valley both with regard to what can be done there, as well as preparation of environmental impact statements relative to any proposed action.

In terms of where we stand, we are not in a position to do anything from a legal standpoint without additional legislation, but we have made plans and——

Senator CHURCH. Are you asking for legislation?

Mr. CUNNINGHAM. We have in the authorization bill a request in the authorization bill, sir.

Senator CHURCH. Have you completed your negotiations with the State of New York?

Mr. CUNNINGHAM. No, sir.

Senator CHURCH. What is the planned method of solidification of this waste?

Mr. CUNNINGHAM. In the case of the West Valley waste, the method which we have looked at which appears to be most promising would be a vitrification process.

That process is further along. We have considered the possibility of some alternative forms, and we have considered possibilities in terms of handling waste in such materials as concrete, as well as glass.

But the method which has been most fully investigated and evaluated is one in which the high level liquid waste would be vitrified into the form of glass logs.

Senator CHURCH. Into the form of what?

Mr. CUNNINGHAM. Glass logs.

Senator CHURCH. What are you going to do with the glass logs?

Mr. CUNNINGHAM. Well, at the present time——

Senator CHURCH. You are going to put them in the permanent depository in the year 2009?

Mr. CUNNINGHAM. It's not quite that bad. We have, as you know, a number of test facilities, a near-surface test facility at Hanford and the Climax Mine at the Nevada Test Site where we are attempting to evaluate data on spent fuel assemblies.

We would also propose, if we had available, glass logs such as these, to test them in these facilities, as well.

Senator CHURCH. You have recently received, Mr. Secretary, an unsolicited proposal to build a laser at Richland Demonstration Plant, which would appear to give you an opportunity to substantially accelerate your program.

My understanding is that this is in connection with fusion and would be a demonstration plant that looks toward the use of this particular method for generating power.

Mr. CUNNINGHAM. Yes, sir. Senator, I believe the particular application——

Senator CHURCH. I do not think I have described this accurately, but I think you know what I am discussing.

Mr. CUNNINGHAM. Yes, sir.

Senator CHURCH. It is a very technical field.

Mr. CUNNINGHAM. I would just say that this particular application of lasers that you are referring to would be utilized in the separation of uranium-235 from 238 and enriching the fuel in that way.

Such a method would either be a supplement or an alternative to the gaseous diffusion and the gas centrifuge program.

Now, we have, as you know, been conducting for some years a classified program on advanced isotope separation technology. This program has been carried on at several of our national laboratories. We have also been informed to a limited extent during this time period of the work which Exxon has been carrying out.

Exxon has made a proposal to us to utilize their technology in the government program. We are presently evaluating that proposal.

I would expect, some time in the early fall, to be able to respond to that proposal in terms of comparing it with the ongoing programs and determining what contribution either the Exxon engineering group or the Exxon technology could make.

Senator CHURCH. You have this under active consideration?

Mr. CUNNINGHAM. Yes, sir.

Senator CHURCH. Well, if my description was not exactly accurate, I hope that, as a nuclear physicist, you will take care of that in the record.

Other members have indicated that they may have written questions to submit to you. We would appreciate your prompt response to those questions.

Thank you for testifying.

The hearing is adjourned.

[Whereupon, at 3:30 p.m., the hearing was adjourned.]

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APPENDIXES

APPENDIX I

Questions Submitted to the Department of Energy and Responses

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Department of Energy
Washington, D.C. 20585

April 17, 1980

Dear Mr. Astrin:

Attached you will find answers to questions submitted to Maxine Savitz, Deputy Assistant Secretary for Conservation and Solar Energy and Bennett Miller, Deputy Assistant Secretary for Solar Energy, Department of Energy, for the hearing before the Senate Committee on Energy and Natural Resources, Subcommittee on Research and Development on March 20, 1980, regarding FY 81 Budget for Conservation and Solar.

If you have any questions please do not hesitate to contact me directly on 252-5777.

Sincerely,

Frank R. Pagnotta

Frank R. Pagnotta
Director
Office of The Secretary

Mr. Al Astrin
Committee on Energy and
Natural Resources
Room 3200
Dirksen Senate Office Building
Washington, D.C. 20510

RESPONSES OF MAXINE SAVITZ

Q. 1A. Why did the Department not request funds for the continuation of the field tests as planned?

A. The $9,000,000 addition to the FY 1980 budget for the fuel cell test program was added by Congress. The preparation of the FY 1980 department budget was complete prior to the availability of those funds, therefore, follow-on funding was not planned. The Department has decided in view of the current budget balancing for the FY 1981 budget that a supplemental request will not be forwarded.

Q. 1B. Does the Department intend to proceed with the demonstration of this technology?

A. The Department does intend to proceed with the demonstration field test of the 40KW fuel cells. The procurement package has been prepared and options for continuation of the program assessed. No decision has been reached on the size of the field test program to be supported.

Q. 2A. What is the status of industrial support for the field test?

A. United Technologies Corporation has offered a reduced fee of approximately $1,000,000 new capital equipment valued at $580,000 and the use of existing capital equipment valued at $2,800,000. The estimated value of this contribution is $2,500,000.

For a 50 fuel cell test program the Gas Research Institute is contributing approximately $4,000,000 to the manufacture of the power plants. Each utility is contributing site preparation and data gathering and analysis. This effort is estimated at $500,000 per site or $14,000,000. Thus, of the entire program the federal share is approximately $21,000,000 and industries share approximately $20,500,000.

Q. 2B. Have the gas utilities pledged co-funding for the field tests? If so, what is their contribution?

A. As noted in A above the gas utilities have pledged approximately $18,000,000 to the program.

Q. 2C. Are there any other conservation programs that have achieved this level of approximately 50 percent co-funding?

A. There have been projects within the conservation and solar energy area that have met or exceeded a 50% cost share. Particularly in the Community Technology Systems area a number of the more advanced development and demonstration projects have costs shares up to 33% Federal, 67% local funds.

Q. 3A. Has procurement action been initiated to fabricate the first field test units?

A. The procurement action to fabricate the first field test units has been initiated.

Q. 3B. Has a contract been signed to fabricate these units? If not, when will a contract be negotiated?

A. The contract has not been signed as of this date. Contract negotations are expected this summer.

Q. 4A. What is the status of the task force report and when will it be released?

A. The task force report has been completed. It is an internal document not intended for publication. A copy with the internal decision memorandum is attached. All fuel cell outlay programs in DOE have been transferred by the Assistant Secretary for Fossil Energy.

Q. 5A. What dollar amount did BCS recommend be provided?

A. BCS recommended that $10 million be added to the budget for the fuel cell field test program.

Q. 5B. What is the status of these additional funds?

A. This recommendation has not been forwarded by the DOE to OMB.

Department of Energy
Washington, D.C. 20585

March 19, 1980

MEMORANDUM FOR Ruth M. Davis
Assistant Secretary, RA

Edward A. Frieman
Director of Energy Research

George Fumich, Jr.
Assistant Secretary, FE

Thomas E. Stelson
Assistant Secretary, CS

William S. Heffelfinger
Director of Administration

FROM: John M. Deutch
Under Secretary

SUBJECT: Decisions on the Recommendations of the Fuel Cell Management Review Task Group

I would first like to express my thanks to the members of the Task Group who participated in this exercise. It is a first-rate effort and the Co-Chairmen are to be congratulated on their diligence.

The report, as well as my own experience, points to two major obstacles in the path of successful fuel cell commercialization. They are the technical improvements which must be made to ensure reliable economic performance, and the institutional and marketing barriers which must be resolved if we are to achieve timely and successful introduction of this technology in our energy system. I am pleased to note that the report recognizes that different sets of talents are necessary to resolve these different problems.

The following are my decisions on the nine recommendations of the Task Group:

Recommendation No. 1: All of DOE outlay programs for fuel cells and corresponding actions should be consolidated with program responsibility vested in the Division of Fuel Cells, Office of Coal Utilization, under the Assistant Secretary for Fossil Energy. This requires that FY 80 funding ($9.5 million) and the associated field test program responsibility be transferred from CS to FE.

Decision: Approved

The Assistant Secretary for Fossil Energy is directed to coordinate transfer of these responsibilities and budget items with the Director of Administration and the Assistant Secretaries for Resource Applications and Conservation and Solar Energy. The transfer should be completed within 30 days.

Recommendation No. 2: Personnel allocations related to direct management of fuel cell hardware procurement and field test outlay projects in CS and RA should be transferred to the Division of Fuel Cells (OCU/FE). This involves the transfer to FE of one position from CS and one position from RA. Consideration should be given to the possible transfer of incumbent personnel.

Decision: Approved, with modification

The transfer of one personnel slot from Resource Applications is approved. No Conservation and Solar Energy slots will be transferred. Consideration should be given to the possible transfer of the RA incumbent to FE. This question should be resolved within the 30-day period.

Recommendation No. 3: Commercialization and industrialization, including market assessment and market development activities, should continue to be the responsibility of the Assistant Secretary for Conservation and Solar Energy for on-site integrated energy systems, and the responsibility of the Assistant Secretary for Resource Applications for utility systems. This requires that funding to support such activities be made available by FE to CS and RA, respectively. ($500K in FY 80 and $1,000K in FY 81 each to CS and RA.)

Decision: Approved, with modification

Funds for these activities at the levels noted by the Task Group will be passed from Fossil Energy to Resource Applications and Conservation and Solar Energy. All future industrialization funds will be provided for within the Fossil Energy budget.

Recommendation No. 4: The Director of the Fuel Cells Division OCU/FE should serve as the DOE representative to the National Fuel Cell Coordinating Group and as the focal point for DOE fuel cell programs.

Decision: Approved

Recommendation No. 5: Program objectives, milestones, and plans as presently contained in the proposed National Plan of the National Fuel Cell Coordinating Group, prepared in cooperation with manufacturers and users groups, should serve as the basis for structuring the DOE program. This anticipates initial commercial service introduction of phosphoric acid utility systems by 1985 and on-site integrated energy systems by 1987.

Decision: Defer to the Assistant Secretary for Fossil Energy in coordination with the Assistant Secretaries for Conservation and Solar Energy and Resource Applications.

The technical state of development and the funds available suggest only a limited field test for the 40 kW systems in order to build industry confidence and gain operational data.

Recommendation No. 6: The fuel cell program should be conducted so as to assure positive measures to foster serious manufacturer competition in the supply of phosphoric acid fuel cell systems for both utility and integrated energy system applications. The program should be directed toward the development of detailed engineering design specifications which would permit such competitive supply by mid-year 1982.

Decision: Approved

Recommendation No. 7: Concurrence by RA and CS should be required with respect to system performance requirements and specifications for fuel cell power plants being developed by FE for electric utility systems and on-site integrated energy systems respectively to ensure that achievable user-oriented system requirements are included in the specifications.

Decision: Approved, with modification

It is the responsibility of the Assistant Secretary for Fossil Energy to ensure that RA and CS have the opportunity to validate specifications developed by the program.

Recommendation No. 8: Consideration should be given to an FY 81 supplemental budget request which would take into account FY 80 congressional actions, and facilitate a timely and effective development and industrialization program for fuel cells. It appears that the supplemental funding needs would approximately double in FY 81 funding request.

Decision: Disapproved

Recommendation No. 9: Fuel cell industrialization planning with DOE should proceed on the basis of specific memoranda of understanding executed between FE and RA with respect to fuel cells for electric utility use, and between FE and CS with respect to fuel cells for on-site integrated energy systems use.

Decision: While formal memoranda of understanding should not be necessary, a general statement of respective roles and responsibilities is desirable.

The responsibility for fuel cell technology development is the clear responsibility of the Assistant Secretary for Fossil Energy. In pursuing that development and the formation of technical specification, the Assistant Secretary for Fossil Energy will consult closely with the Assistant Secretaries for Resource Applications and Conservation and Solar Energy to ensure that such specifications reflect the valid requirements of the respective end-use sectors.

The responsibility for the identification and amelioration of institutional and marketplace barriers which might tend to inhibit the successful introduction of fuel cell technology is the clear responsibility of the Assistant Secretary for Resource Applications for utility systems, and the Assistant Secretary for Conservation and Solar Energy for the OS/IES 40 kW systems. There should be clear recognition by all parties that technology development and barrier mitigation are closely interrelated elements leading toward a common goal. Close, continuing consultation between FE, RA, and CS on these items is both essential and expected.

While field test programs and demonstration projects are primarily technology development exercises, it is recognized that the institutional experience gained from tests are equally valuable to the overall program objectives. Therefore, the Assistant Secretary for Fossil Energy will work closely with the Assistant Secretaries for Conservation and Solar Energy and Resource Applications on the formulation of plans for any new field test or demonstration programs.

cc: Charles Duncan
John Sawhill
Deanne Siemer
Jack Hewitt

6. QUESTION: In a *Washington Post* series run last October on the Pacific Northwest kilowatt crisis, it was noted that the Northwest is home to 10 aluminum plants which use 1/5 of all the region's electricity and 1/3 of all electricity from the Federal dam system. The article concluded that if big aluminum were not in the Northwest, there would currently be no energy shortage.

A. Considering this fact, do you think your industrial process efficiency program is giving enough attention to the aluminum industry?

B. Another large-electric consumer in the Northwest is the paper-processing industry. Do you think sufficient attention has been provided to improving the process efficiency of this large industry?

ANSWER: A. A total of $5.8 million is included in the President's budget for FY 1981 for increased efficiency in aluminum processes, focusing on the most energy intensive process step: aluminum reduction. The three related projects (direct reduction, improved cathode and inert anode) are appropriately funded for the present phase of development. Since 10 percent of the FY 1981 request is for the aluminum industry, which consumes about 4 percent of the industrial energy, it is considered an appropriate allocation.

B. Approximately 7 percent of the President's budget for FY 1981 is directed toward energy conservation in the paper industry, which consumes about 9 percent of industrial energy. A total of $4.1 million is requested for five projects for improved paper making (industrial heat pump demonstration, computer controls and sensor development for paper processes, mechanical dewatering, cold corrugation processes and freeze concentration of black liquor). The level of funding in each case is considered appropriate. In addition, FY 1981 activities in hydropyrolysis of black liquors were funded in FY 1980 and work is continuing.

Although, as in most areas of activity, additional efforts could be undertaken, ~~but~~ the above mentioned projects are the most cost-effectiveness that have been identified to date.

Q. 7. Why do you suggest on page 13 of your testimony that the $2.1 million reduction in RD&D activities for urban waste "is the result of reduced requirements"?

A. The urban waste area was increased by $3 million in the FY 1980 budget by Congress. The $10.9 million budget as submitted by the Administration represents a small increase from FY1979. Several of the projects started in prior years are nearing completion and therefore their funds requirements are reducing. There is no actual decrease in the overall RD&D needs to fully develop and commercialize technologies that provide options in size, markets and institutional arrangements, to change municipal waste from a disposal problem to its utilization as a resource.

Q. 8. Why have you decided to emphasise the development of small-scale systems in FY 1981 for the urban waste program?

A. There are a number of large-scale technologies in the final commercialization stages of development. The program continues to support specific research needs in these and other large-scale technologies. However, only 50 to 60% of the waste stream is a target for the large-scale facilities. The contemplated small-scale techniques will expand the target waste stream to approximately 90%. In addition, small-scale units have the potential to lessen the marketing and siting problems faced by the large-scale units.

RESPONSES OF BENNETT MILLER

Q1. In response to a question submitted to Secretary Duncan during the February 4, DOE 'FY 81 Budget Hearing, the Secretary indicated that DOE staff is now working on a number of new legislative initiatives, all of which are in the formative stages. In addition, as you are aware, several conservation programs are being proposed in S. 932, which is presently in conference. What additional conservation initiatives is your Department pursuing?

A1. DOE presently has one legislative conservation initiative--the Energy Management Partnership Act (EMPA). The Administration proposal is an important new initiative designed to support the development of a long-term structural solution to the nation's energy management problems.

The key objective of EMPA is to build a framework for a mutually supportive energy partnership among all levels of government to assist the national effort to reduce consumption of scarce energy resources. EMPA would establish a consistent framework for States to identify energy conservation and energy supply targets and for States and local governments to design programs and activities to address those opportunities. Attached is a copy of Dr. John Sawhill's February 25, 1980 testimony on EMPA before the full Senate Committee on Energy and Natural Resources.

In addition DOE, policy staff is examining several other possible legislative initiatives which remain in the formative development stage.

STATEMENT OF

DR. JOHN C. SAWHILL
DEPUTY SECRETARY
U. S. DEPARTMENT OF ENERGY

FOR

A HEARING BEFORE THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

February 25, 1980

Mr. Chairman:

Events over the past several years dramatically illustrate many of the weaknesses and pitfalls inherent in pursuing any national policy without the full participation of State governments and local municipalities. Nowhere is this more true than in energy. State and local governments played major roles during the gasoline shortages experienced in many regions of the country last year, as well as in other fuel emergencies over the past decade.

There are some excellent State and local programs being implemented for conservation and renewable resource development that have been supported with and without Federal assistance.

The problem, Mr. Chairman, is that too many other States and local governments are not able to make the contributions to our energy problems that they would like to make.

If our national effort to reduce consumption of foreign oil and to encourage a transition to renewable resources is to succeed, we must build a framework for a mutually supportive energy partnership among all levels of government. With these objectives in mind, the Administration has proposed the Energy Management Partnership Act or "EMPA."

With regard to the States, we believe EMPA is needed for the following reasons:

First, EMPA would encourage States which do not already have an effective energy management capability to develop their own overall energy supply and conservation plan in cooperation with local governments.

Second, EMPA would consolidate and simplify administrative procedures for three major existing grant programs -- the EPCA and ECPA State Energy Conservation Programs and the Energy Extension Service. It would also permit States to consolidate applications for other assistance programs administered by DOE and would provide States with greater flexibility in the use of Federal funds under such programs. By cutting red tape and giving States greater flexibility to tailor programs to meet their needs, more money will be available for implementing energy programs, and less required for grant administration.

Third, EMPA would provide funding to State and local governments for conservation and the development of renewable resources such as solar energy. State and local governments must work to remove the technical, economic, and institutional barriers which stand in the way of increased renewable resource use. They are important partners with the Federal Government in the drive to achieve the President's national goal of 20 percent solar energy use by the year 2000.

Fourth, EMPA would provide support for State energy emergency planning. Some of the activities included in such planning are State plans for set-aside of petroleum products and other energy supplies, allocation of fuels in short supply during a period of supply disruption, monitoring of supply and consumption, and developing and implementing other emergency measures which are responsive to State needs.

And fifth, EMPA would provide Federal funds to help States cover the costs of other Federal or State initiated energy programs.

In these five ways EMPA will help to increase the role of State and local governments in managing our energy problems, and provide a framework of Federal, State, and local activities. This kind of cooperative framework is needed if the Nation is to succeed in its effort to achieve an orderly transition away from oil imports and depletable fuels, towards a domestically-based renewable resource energy system.

The State Energy Plan

An important part of this legislation is a requirement that each participating State develop and carry out a State energy plan. The purpose of the plan, which would be updated every other year, is to allow States to assess their current energy situation, forecast future supply and demand, and develop supply and consumption targets.

The capacity of a State to forecast supply and demand we believe is vital in an age where, for example, the construction of new large-scale power generation facilities may take 6 to 12 years. Better information from States will also improve the quality of information available to Federal decision-makers. Such forecasts should be helpful in pinpointing problems and in targeting State-sponsored programs to high payoff areas.

Under the EPCA and ECPA State Energy Conservation Grant Programs established in 1976 and 1977 the States have been asked specifically to develop State energy conservation plans that would consist of State laws, policies, programs, and procedures to improve efficiency in the use of energy and that would reduce State energy consumption by a target of 5 percent or more from projected energy consumption in 1980.

Many States have already established programs that reflect major commitments toward realizing their energy conservation potential. Several specific examples may be helpful. Montana's energy audit program computes the efficiency with which the State's government buildings use energy and identifies structures where consumption exceeds the norm. During the first 10 months of operation, the State government used 126 billion BTU's less than it did the previous year. The Missouri Energy Office has joined with a consortium of 30 major industries within the State to establish an industrial clearinghouse to facilitate research and information exchange among industries completing or considering major energy conservation initiatives or changes in fuel use. As a leading farm State with a highly mechanized agricultural production system, Kansas is highly dependent on energy imports. The Kansas Energy Office has therefore helped to develop management plans to assist Kansas farmers in conserving energy in 13 specific agricultural processes and systems.

As encouraging as these (and many other) examples of programs supported by EPCA and ECPA may be, they focus on but one facet of what must be each State's comprehensive role in addressing its energy future. It is the desire to encourage and assist each State to address all aspects of its energy responsibilities that has led to the Administration's proposal of the Energy Management Partnership Act.

EMPA would continue to encourage vitally important State energy conservation initiatives, but it would also go further to require each State to develop and implement a comprehensive State energy plan.

This State energy plan consists of the following elements:

- A description of State energy supply and demand and of its energy goals and policies to include:
  - a) A forecast of future energy consumption patterns,
  - b) A description of the likely sources for energy supply, both to meet projected consumption and to be sent outside the State,
  - c) A projection of the need for electric power generation facilities and actions to facilitate siting; and,
  - d) A projection of the need for other major energy supply facilities.
- A management plan to include:
  - a) Identification of the major opportunities for energy conservation and a description of State energy conservation goals and objectives for such consumption sectors.
  - b) Description of the programs the State will carry out to meet its overall energy goals and objectives.
  - c) Program objectives by which the State's progress will be monitored and assessed.
- A description of how the State plans to implement the energy conservation and renewable resource requirements of EMPA (Sections 356 and 357, respectively), which

build on the previous EPCA and ECPA programs and on significant recent developments including the President's Domestic Policy Review of Solar Energy and his Solar Message.

- An energy emergency plan coordinated with the plans of DOE.
- A description of the provisions for participation of local governments, Indian tribes, and the public.
- A description of the means by which the State's energy planning under EMPA will be coordinated with the plans and programs of State agencies and units of local government for economic development, transportation, environmental protection, and coastal management.

It is important to note that while EMPA requires all States to address the overall dimensions of their energy situation, it allows for considerable flexibility as to how each State, with its unique set of opportunities, resources, and contraints, would respond to help achieve our national energy goals.

Local Government

The cooperative framework that we envision would not be complete without full participation of local governments -- from the stage of developing the State energy plan through its implementation. Even under the existing State programs, some

States have voluntarily taken advantage of the capabilities of local governments to achieve energy conservation.

The advances made by local government pioneers in energy conservation such as Davis, Portland, and Seattle, are by now well known. But many other cities and counties have also undertaken successful efforts to improve community energy efficiency, both with and without "seed money" from Washington. Two illustrations would be useful. Oakland's conversion of streetlights to energy-efficient high-pressure sodium lamps saves over 30,000 barrels of oil and $900,000 a year. Nassau County, New York, uses computers to carefully monitor energy use in government buildings which has reduced consumption by 20 to 25 percent.

We now consider a State/local energy partnership to be an essential ingredient of the institutional structure the United States should use to manage its energy affairs creatively and effectively. Thus, we propose through EMPA to formally recognize an expanded energy role for local governments; EMPA would expand the role of local government in four ways:

- EMPA ensures direct local government involvement in developing the State energy plan.

- Local governments would share the States' allocation of funds in proportion to their responsibilities under the State energy plan.
- States would be permitted to pass through an additional amount of federal funds directly to local governments.
- We are preparing an amendment to EMPA which would authorize a $50 million program of grants to local governments for energy conservation activities. This would amend subpart C of S. 1280, which would otherwise authorize $5 million for use by local governments for "Special Energy Projects."

Conservation, Renewable Resources, and Energy Emergency Measures

EMPA funds for program implementation will be focused on energy conservation programs, renewable programs, and energy emergency measures. Because the promotion of energy conservation, development of renewable resources, and implementation of emergency measures must rely heavily on decentralized action, it is extremely important to enlist State and local governments as fully as possible in the effort to achieve these important national energy objectives. As DOE findings indicate, conservation and renewable resources are the two energy sources which are most capable of increasing energy stocks available to the Nation in the near term.

EMPA requires each State receiving funds under the Act to provide for certain energy conservation programs and measures. These include the establishment of energy extension service activities, the implementation of the Building Energy Performance Standards developed under Title III of the Energy Conservation and Production Act, and a traffic law or regulation which permits right-turn-on red. States must also develop a management plan which identifies those consumption sectors where State energy conservation measures could have the greatest impact, and a description of State objectives for energy conservation in these sectors. States must consider continuing the implementation of lighting efficiency standards for existing State and local government buildings; programs to promote the use of carpools, vanpools and public transportation; and mandatory State procurement standards which promote energy efficiency -- all programs currently required under the Energy Policy and Conservation Act.

In order to insure appropriate State support of renewable resources, each State submitting a State energy plan under EMPA must include in that plan a set of provisions to remove barriers to the use of renewable resources. The steps which States would consider when developing such a renewable resource plan include:

(1) Measures to increase participation by financial institutions in the financing of renewable resource utilization.

(2) Intervention by the State in electricity and gas utility rate proceedings, where appropriate, to insure that rate schedules do not discriminate unfairly against the use of renewable energy resources.

(3) Assessment of the applicability of using renewable energy systems in State and local government buildings.

(4) Actions to encourage application of renewable energy systems to low income families, rural residents, and agricultural uses.

(5) Information activities to promote consumer protection.

EMPA further requires each State to establish an energy emergency plan which would provide for such measures and activities as: the administration of State set-aside programs for petroleum and other energy supplies; a program for allocating fuels in short supply and for restraining demand for these fuels during times of energy emergency; and the administration, enforcement, and implementation of the prescribed State actions in a Federal mandatory energy emergency plan or measure, upon the direction of the Secretary of the Department of Energy. We are considering a technical amendment to EMPA which would reflect the specific requirements of the Emergency Energy Conservation Act recently passed by Congress.

States would be required to spend 60 percent of the financial assistance provided under the bill on energy conservation and renewable resource development, along with emergency planning. Beyond this point, however, each State is free to set the direction of its goals and priorities, within the bounds of the required elements of the State plan, as described previously, and within the bounds of Federally mandated programs funded under EMPA and other programs.

Thank you very much for the opportunity to testify today. I will be happy to answer any questions you may have.

Q2. Under the Emergency Energy Conservation Act of 1979, DOE established voluntary State gasoline consumption targets for the first three months of 1980.

a. Knowing that you have little data at this time, how would you characterize state compliance with these targets?

b. When will you transmit targets for the 2nd quarter to the States?

c. What has DOE done to reduce the difficulties in gasoline consumption data and reporting procedures?

d. Does DOE have an effective gasoline use monitoring and data base system in place that could be used to establish mandatory gasoline targets should an energy emergency develop?

A. a.) 1st Quarter 1980 targets announced in December represented a 7.1% decrease on the average for all States and D.C. over quarter 1979 levels.

The FHWA data, which is used in setting and monitoring targets, includes no State figures for 1980, as of yet.

However, two States have called DOE to discuss their January gasoline numbers and how they comply with their January targets:

California-January 1980 consumption was 2% above target.

Massachusetts-January 1980 consumption was 5% above target.

Oregon State officials called and reported, as of December, 1979, levels of gasoline consumption were down from the previous target so much that 1st quarter 1980 target should be met easily, if not exceeded.

2A (cont'd)

The U.S. levels of gasoline consumption for 4th quarter 1979 showed decreased levels, which, if continued into 1980, would likely show average State compliance to targets to be within 3% or so.

b.) Letters announcing the targets were signed by Deputy Secretary Sawhill and sent to Governors and Mayor, D.C. on Wednesday, March 19, 1980. DOE announced the targets to the public on March 20, 1980.

c.) FHWA gasoline data, reported by States from sales tax data, was found to be irregular on a monthly basis for many States.

Twenty-two States have revised their data since gasoline targets were first developed in December to rectify many of the original monthly irregularities. (See accompanying table)

To minimize further the monthly variability of the sales tax data, the methodology used only 12-month sums of the monthly data in calculating targets. This procedure produces annual data which is far more regular.

DOE is continuing to work with State officials where further corrections of the data are appropriate.

2A (cont'd)

As regards reporting procedures, the issue is discussed in the following section (d).

d.) DOE has been working with DOE and the States in developing a standardized reporting form for the MF-33 data and in reducing the lag between each month and the date we receive their data. A form has been developed and sent to the States' DOTs for review. It is currently planned that the form will be distributed in April for the States to use in reporting April data 45 days after the month. Some States have indicated that they cannot meet this deadline and that they cannot report all the data requested on the form. If the States can provide at least the gasoline data requested on the form and if they can report the data within 45 days after the end of the month, this data system which DOE will continue to work with States to rectify will be adequate for setting and monitoring gasoline targets, although it will still possess some deficiencies.

DOE will continue to work with States to rectify those deficiencies still remaining in the data system.

DOE has received letters from 12 States that are not content with the present data sources being used or the method of calculating targets from their State.

2A (cont'd)

Almost universally the States' recommendations for resolving their concerns are either at variance with the provisions of EECA, reflect very individual objectives which would be vigorously opposed by most other States or require a methodology far more complex than could be developed within the foreseeable future.

Q3. The Standby Federal Emergency Energy Conservation Plan (SFP) was released on February 4, 1980, and published in the Federal Register on February 7, 1980, as an Interim Final Rule.

The SFP is intended both as a guide to States in developing State Emergency Energy Conservation Plans and as a viable plan to be implemented in those States which are unable to meet energy conservation targets which may be established by the President.

How many States have accepted the methodology and the related data elements?

A. It is first appropriate to clarify the thrust of the question. It is presumed that the "methodology and related data elements" referred to are related to the various emergency energy conservation measures set forth in the SFP and not to the gasoline targets methodology and data which are discussed in the previous question (#2).

Although major parts of the SFP were published as interim final rules on February 7, 1980, the Department of Energy has solicited and received public comment on all aspects of the Federal Register notice (including interim final and proposed provisions) through April 7, 1980. To date, we have conducted eight public hearings and received more than 26,000 individual letters, mailgrams and telegrams containing comments on various aspects of the SFP.

We are in the process of sorting through, reviewing and analyzing this large volume of testimony and mail in preparation for determination of appropriate action with respect to establishing final rulemaking. The highest priority has been assigned to the review of comments which may have been received from State energy offices and State Governors. The sorting process is not yet complete, however, Q3 (cont'd)

and we do not have a definitive view of whether the States individually, or collectively, are in accord with the measures and associated analyses that were published in the Federal Register notice on February 7, 1980.

This task has been made somewhat more complicated since only six States testified directly at the hearings and the National Governors' Association did not request to testify.

If a review of the written comments and testimony does not yield sufficient information to allow the Department to reach a logical conclusion with respect to the level and extent of State acceptance of the measures (and the associated analytical methodologies and data), it will be necessary to affirmatively seek such information and opinion.

In the meantime, the CS Office of Transportation Programs, in conjunction with the CS Office of Emergency Conservation Programs, is preparing additional materials which will, when disseminated, provide the States with more detailed information and analytical methodologies than were feasible to supply with the Federal Register notice of February 7, 1980. This additional material has been developed, thus far, in consultation with an ad hoc working group established by the National Governors' Association to insure as much as possible its validity and utility, as well as to insure expeditious dissemination to all States upon its completion.

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United States Senate

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, D.C. 20510

April 2, 1980

Dr. Bennett Miller
Deputy Under Secretary for Solar
Department of Energy
Washington, D.C. 20585

Dear Dr. Miller:

As I indicated at the conclusion of the March 19th Subcommittee on Energy Research and Development hearing, I would appreciate having your written comments on several matters which we were unable to cover during the hearing.

The questions are as follows:

1. In your statement you note that the Department is doing extensive research on the development of conversion technologies for lignocellulosic agricultural and forest residues to produce ethanol. Our hearings last year showed that at present there are five developing technologies which will utilize this type of feedstock. If this nation is to have a large-scale gasohol program, we must be able to use this feedstock, and therefore the earliest possible demonstration of a successful commercial process in very important. Please describe the DOE program for the development of systems to use lignocellulosic feedstocks, and when we can expect the earliest demonstration of a commercial process.

2. You characterize the biomass energy systems program of research and development for ethanol production as "comprehensive." Are you satisfied with the degree of crop research being done to improve the yield of existing crops and to develop new crops for ethanol production? Could you indicate the status of your interagency agreement with the Department of Agriculture to perform some of these R & D activities?

3. What do you consider to be the optimum scale of production for on-farm conversion of crops to ethanol?

4. What, if any, is your Department's level of participation in the Department of Agriculture's 1977 Food and Agriculture Act alcohol plant demonstrations?

5. The Department of Commerce and Agriculture have announced ~~$1~~55 million in loan guarantees for alcohol fuel production

facilities. How does this program interrelate with the alcohol fuel production plants that would be funded under the Department of Energy's alternative fuels program, pursuant to Public Law 96-126?

6. On page 15 of your testimony you say that SERI is designated as the National Alcohol Fuels Information Center. Yet, the "principal document" for distribution, "Fuel From Farms", which was developed by SERI, is available for public distribution through the Technical Information Center at Oak Ridge, Tennessee. Why is the distribution point almost 1,000 miles away?

7. In the solar applications budget, you mention $20 million for agricultural and industrial process heat applications. Could you summarize how the priorities for this program were established and what is the likely future direction for the program?

8. A recently-released GAO report suggests that "DOE has developed no overall strategy for identifying potential international energy R&D programs, either bilaterally or through IEA, to complement its domestic R&D efforts.

   a. Do you agree with this criticism?

   b. If a problem exists, how do you plan to correct the situation?

9. Will additional FY80 and 81 funding be requested to support two contractors for the Advanced Multi-Megawatt Wind Turbine (MOD-5)? If not, how do you see this program proceeding?

10. What are the DOE plans for utilization of the 4th MOD-2 unit for which the supplier currently has long-lead time components on order?

11. What are DOE's R&D plans past the MOD-5 and MOD-6 procurements?

12. Does the DOE see value in acceleration of current R&D programs if additional funds were made available in supplemental FY80 appropriations and increased FY81 budgets? What are the cost/benefits of additional funding?

13. Can you give me your assessment of the potential of wind turbines for irrigation purposes? Is there any plan to expand the demonstration of this application?

14. On page 4 of your testimony you suggest that by "judiciously selecting" to advance only the leading technologies in the photovoltaics programs, you can meet your stated goals. You also suggest that your key thrust in advanced R&D is to "pick winners." Could you provide me with an indication of how this selection process works?

    a. What attempts have you made to include small business concerns in the competition?

15. Would you comment on John Deutch's recent statement that, "In solar, I believe the 20 percent target (in 2000) is exceedingly ambitious. For prudent planning purposes I can't get myself to believe much above 10 percent, including biomass and wind." Do you agree?

Your prompt reply to these questions would be most appreciated.

Sincerely,

Frank Church

Frank Church, Chairman
Subcommittee on Energy
Research & Development

Department of Energy
Washington, D.C. 20585

Honorable Frank Church
Chairman, Subcommittee on Energy
  Research and Development
Committee on Energy and
  Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed are the answers to the questions contained in your letter of April 2, 1980. I hope they adequately address your concerns.

Please contact me if you have any further questions.

Sincerely,

Bennett Miller
Deputy Assistant Secretary
  for Solar Energy (Designate)

Enclosure

Follow-up Questions and Answers to the March 19, 1980 Hearing by the Senate Subcommittee on Energy Research and Development

Q.1. In your statement you note that the Department is doing extensive research on the development of conversion technologies for lignocellulosic agricultural and forest residues to produce ethanol. Our hearings last year showed that at present there are five developing technologies which will utilize this type of feedstock. If this nation is to have a large-scale gasohol program, we must be able to use this feedstock, and therefore the earliest possible demonstration of a successful commercial process is very important. Please describe the DOE program for the development of systems to use lignocellulosic feedstocks, and when we can expect the earliest demonstration of a commercial process.

A.1. The DOE program for the development of systems using lignocellulosic feedstocks focuses on improving system efficiency, decreasing process cost, and increasing the size of units for processing. These objectives are being met by sponsoring activities such as laboratory-scale studies, development of process development units, and design studies for scaling up to larger units for promising concepts. The research and development studies sponsored by the program aim at improving fermentation technologies using innovative concepts such as enzymatic hydrolysis.

In addition to continuing the ongoing research, the development of systems to use lignocellulosic feedstocks for the production of alcohol fuels will consist of funding a 1 ton per day feedstock conversion experiment at the University of Arkansas. This is currently in negotiation. The next step is to support a 50 ton per day engineering application experiment leading to a 1000 ton per day production plant to become operational in the mid-1980's.

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AF-Potts
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Q.2. You characterize the biomass energy systems program of research and development for ethanol production as "comprehensive." Are you satisfied with the degree of crop research being done to improve the yield of existing crops and to develop new crops for ethanol production? Could you indicate the status of your interagency agreement with the Department of Agriculture to perform some of these R&D activities?

A.2. It is our view that we do have a balanced comprehensive program in crop yield research for the production of feedstock for ethanol. It consists of studies with sweet sorghum at Battelle-Columbus, woody crops at Oak Ridge, and herbaceous species at SERI. With the increase in concern with inflation related in part to the importation of crude oil and its displacement by the use of alcohol fuels, we will continue to review carefully this effort and adjust as conditions dictate. The proposed interagency agreement between the Office of Alcohol Fuels and the Department of Agriculture was provided to USDA on March 10, 1980, and accepted by USDA on April 5, 1980.

Q.3. What do you consider to be the optimum scale of production for on-farm conversion of crops to ethanol?

A.3. We believe that it is premature to establish, at this point in the development of a new and fledgling industry, the optimum scale for an on-farm ethanol plant. The answer, of course, depends on many factors: the size of the farm, the crops being raised, the number of crops per year, the fertility of the soil, the availability of irrigation water, the market for the co-products, the community support, and the availability of capital to finance the enterprise. It also depends on whether the "farm" is producing the feedstock or consuming the distillers mash, or both. At the lower end of the spectrum, the on-farm plant could range in size from 1,000 to 50,000 gallons per year. At the upper end, the size could range from 250,000 to 2,000,000 gallons per year and still be classified as an on-farm plant. As the industry matures, we will be able to be more definitive. In the meantime, we believe flexible classifications are appropriate.

Q.4. What, if any, is your Department's level of participation in the Department of Agriculture's 1977 Food and Agriculture Act alcohol plant demonstrations? .

A.4. The Department of Energy has not been involved in any of the projects proposed or approved by the Department of Agriculture under the 1977 Food and Agriculture Act.

Q.5. The Department of Commerce and Agriculture have announced $155 million in loan guarantees for alcohol fuel production facilities. How does this program interrelate with the alcohol fuel production plants that would be funded under the Department of Energy's alternative fuels program, pursuant to Public Law 96-126?

A.5. Both the Economic Development Administration (EDA) in the Department of Commerce and the USDA programs have allocated specific amounts under existing financial assistance programs to be set aside for alcohol fuels production facilities. In contrast, the funds provided to DOE through Public Law 96-126 are allocated to all synthetic fuel technology feasibility studies and plant construction dedicated to synthetic fuel production. After all proposals solicited through P.L. 96-126 have been received and evaluated, an appropriate allocation of the amounts available will be made between the competing technologies. Only those alcohol plants that produce more than 1 million gallons per year will be eligible to receive P.L. 96-126 funds.

Neither EDA nor USDA can fund feasibility study grants or cooperative agreements as is possible through P.L. 96-126. Nor can they provide purchase agreements or price guarantees. Generally, EDA will not provide loan guarantees for plants larger than 5 million gallons per year. USDA can fund plants producing up to 20 million gallons. Arrangements are currently being developed between DOE, USDA, and EDA for DOE to provide technical evaluation of proposed alcohol fuels projects if so requested by other agencies. Additional interagency arrangements and agreements are also being developed to maximize benefits of all federal programs related to alcohol fuels.

pages tightly bound

Q.6. On page 15 of your testimony you say that SERI is designated as the National Alcohol Fuels Information Center. Yet, the "principal document" for distribution, "Fuel From Farms," which was developed by SERI, is available for public distribution through the Technical Information Center at Oak Ridge, Tennessee. Why is the distribution point almost 1,000 miles away?

A.6. The Technical Information Center (TIC) at Oak Ridge, Tennessee, was selected to assist SERI in disseminating what we correctly anticipated would be an extremely popular document. TIC is the principal organization for distributing reports from all DOE contractors and, as such, has mechanisms in place for dealing with large numbers of requests. SERI also distributes about 20 percent of the total copies for its day-to-day needs for individual copies. We have arranged for the printer to deliver "Fuel From Farms" directly to Oak Ridge for appropriate handling. Our intent is to capitalize on the experience and capabilities of each organization in meeting the tremendous public interest for this document. We think the system in place now does this quite efficiently.

Q.7. In the solar applications budget, you mention $20 million for agricultural and industrial process heat applications. Could you summarize how the priorities for this program were established and what is the likely future direction for the program?

A.7. Solar Agricultural and Industrial Process Heat (SAIPH) applications are given high priority among the viable applications for solar thermal systems and solar technology in general because the industrial heat market is large and the agricultural market permits early economical applications. Solar heat can be used to displace fossil energy in applications in the range of 150° to 600°F with current technology and up to 1100°F with second-generation systems now under development.

SAIPH priorities are established by the need to address AIPH applications capable of using current technology. As higher temperature systems move along the development path toward commercial readiness, they will be included in the applications program. The split in funding between agricultural and industrial systems is determined by the greater market potential of the latter. In FY81, $4 million will be spent to continue development and demonstration of low-temperature agricultural systems and $16 million will be used to fund the construction and operation phase of industrial hot water and steam projects that were begun in FY79 and FY80.

In addition to the market development funds identified, the funding for systems development relative to these applications has been requested for improving both low-temperature and mid-temperature parabolic trough collector systems. This technology has a high priority in solar thermal market development efforts because of the greater industrial and applications experience to date, resulting in a more mature industrial base than for other solar thermal technologies.

The future direction of this program will be to continue development of low-temperature agricultural and higher temperature industrial applications.

Agricultural Programs will stress multipurpose systems to extend the seasonal use for applications such as grain drying and animal shelters. On-the-farm cost-shared projects will be continued.

Industrial Programs will initially concentrate on the earliest and most cost-effective applications to encourage mass production of commercially viable solar systems. Using solar to provide steam for enhanced oil recovery appears to be an economical near-term application of solar, which displaces oil currently burned for this purpose. More difficult applications will be addressed as cost-effective high-temperature systems become available through the systems development program.

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Q.8. A recently released GAO report suggests that "DOE has developed no overall strategy for identifying potential international energy R&D programs, either bilaterally or through IEA, to complement its domestic R&D efforts."

a) Do you agree with this criticism?
b) If a problem exists, how do you plan to correct the situation?

A.8. (a) No, we do not agree with the above criticism. The following description of goals is provided to back-up this answer.

Goals and Objectives

The goals of the international solar energy program are (1) to accelerate and expand solar energy use in the United States by increasing U. S. technical capabilities through international technical cooperation and by strengthening U. S. industry through increased export of solar systems and (2) to accelerate and expand solar energy use world-wide by increasing the technical capabilities of other nations through international technical cooperation and by promoting the use of solar systems overseas. These goals are seen as generally complementary and mutually reinforcing.

In addition, the solar international program office has a well-defined goal in negotiating (seeking and responding to) cooperative international R&D activities. That goal is to achieve U. S. program benefits at least commensurate with the cooperative program costs (including resources in funds, staff, and technology background) contributed by the United States and its representatives.

Strategy

The strategy of the international solar program consists of two principal parts, which are seen as complementary to domestic technology development and commercialization strategies. The first part involves a core strategy that is based on the anticipated mutually reinforcing relationship between the development and use of solar energy technologies in the United States to their development and use overseas. The second part consist of a set of corresponding beneficial effects of this core strategy.

The core strategy assumes that research, development, and adaptation of solar systems in the United States for overseas applications will promote the development of a number of overseas solar projects, which will, in turn, lead to increased use of these systems in higher energy cost sectors overseas as the systems are shown to be reliable and cost-effective.

Because there are more high energy cost markets overseas than in the United States, it is expected that this increased use (augmenting U. S. system use) will mean significantly increased production volumes for U. S. solar industries. These increases in production should yield opportunities for increased efficiencies of scale and consequent significant reduction in system costs. These reduced costs should then gradually promote further increases in solar technology use in both the United States and the lower energy cost sectors overseas. Accordingly, the benefit of this plan is seen as a substantial acceleration of solar system use in the United States and world-wide, over what would be expected if the United States did not actively pursue an international program.

This sequence of events would also have a number of corresponding effects that are seen as benefiting other nations as well as the United States. These initiatives should be expected to have a beneficial effect on U. S. technology development and system reliability. In addition, overseas projects would provide increased industry exposure and experience with energy needs and conditions abroad, and these projects would provide an opportunity for the United States to pursue programs to serve important foreign policy objectives. Furthermore, the increased experience with overseas projects would provide the means for increasingly effective assistance to developing countries in meeting their energy needs with solar and renewable energy systems. Increased use abroad should further result in increased trade in solar-related goods and services, with a substantial U. S. share; and the technical and industrial infrastructure would be expanding in both the United States and overseas. As the process matures to substantial levels of solar use in the United States and abroad, significant beneficial effects may be expected with regard to relative reductions in oil dependence and an improved balance of trade.

Nature of Cooperative Activities

In general, international cooperative activities of a technical nature originate in one of three ways: (1) in response to initiatives from foreign governments or other groups abroad (2) as the result of high-level commitments of the administration or (3) as the result of needs and opportunities identified by programmatic or policy elements within DOE. Some international solar agreements have been active since 1974, before the formation of either DOE or its predecessor organization, the U. S. Energy Research and Development Administration.

Some criteria for developing and evaluating potential international cooperative activities are as follows:

- Potential benefits to the domestic program:
  - Filling domestic program gaps
  - Accelerating achievement of program objectives
  - Reducing costs to the domestic program
  - Utilizing overseas technologies and facilities
  - Broadening the pool of technical talent, approaches, and ideas.

- **Potential use of U. S.-developed energy technologies abroad and development of export market opportunities for U. S. industry:**
  - **Acquiring overseas project experience for U. S. industries**
  - **Promoting U. S. technology for overseas needs**
  - **Accelerating production to reduce equipment costs**
  - **Identifying markets and export products.**
- **Potential reduction in domestic and foreign demand for imported oil:**
  - **Accelerating U. S. deployment of new energy technologies through increased production economies**
  - **Stimulating the introduction and use of alternate energy systems abroad.**
- **Potential support of U. S. energy policies:**
  - **Improving energy relationships with specific countries (including key oil exporters)**
  - **Supporting international efforts to provide energy alternatives**
  - **Promoting U. S. nuclear nonproliferation policies.**

(b) In light of our answer in (a) above, it is our opinion that a problem does not exist.

Q.9. Will additional FY80 and 81 funding be requested to support two contracts for the Advanced Multi-Megawatt Wind Turbine (MOD-5)? If not, how do you see this program proceeding?

A.9. No, additional FY80 and 81 funding will not be requested for these contracts. The present FY80 budget and the President's budget request for FY81 will provide for proceeding with two competitive contractors for the development of the MOD-5 Wind Turbines. The final projections of total estimated cost (TEC), and the commitment to fabricate one or both systems will be made during FY81 and will affect FY82 and later year funding requirements.

Q.10. What are the DOE plans for utilization of the 4th MOD-2 unit for which the supplier currently has long lead time components on order?

A.10. The long lead parts and materials beyond those necessary for the currently planned three MOD-2 Wind Turbines will be maintained as spares until the equivalent parts are inspected, assembled, and found satisfactory during fabrication of the first three wind turbines. We are discussing with the Department of Interior's Water and Power Resources Service (WPRS) the possibility of providing those parts to them if they decide to utilize them in their wind energy systems verification unit test program. We anticipate a decision by Fall 1980 to determine which spare parts are available, and to determine if this is a mutually agreeable procedure, of value for developing and commercializing wind power. In exchange for the parts, DOE would receive engineering data and test results.

Q.11. What are DOE's R&D plans past the MOD-5 and MOD-6 procurements?

A.11. We anticipate that the MOD-5 will be the last large-scale horizontal axis development program. Hopefully these two machine designs will reach cost and performance goals that will be competitive in broad commercial applications. An additional generation of intermediate-size systems development may be necessary beyond the MOD-6. The cost goals in this size range are challenging and the MOD-6 may not be able to reach the 4c to 5c per kilowatthour needed for broad commercial markets. Also some questions remain about the long-range market for these machines. Consequently, there may be some modification of technical requirements for this class of machines as designs evolve; field tests of prototypes are conducted; and various markets in power system, industrial, and agricultural applications are examined in more depth.

Q.12. Does DOE see value in acceleration of current R&D programs if additional funds were made available in supplemental FY80 appropriations and increased FY81 budgets? What are the cost/benefits of such funding?

A.12. An R&D program can always find uses for increased funding. The crucial question, as you have pointed out, is the marginal benefit of such funding. We think that our FY80 budget and FY81 request represent a balanced program which follows a prudent schedule of development and investigates a sufficient number of approaches to using wind energy. In our opinion, the value of accelerating our wind R&D activities would not equal the cost, given current circumstances.

Q.13. Can you give me your assessment of the potential of wind turbines for irrigation purposes? Is there any plan to expand the demonstration of this application?

A.13. The irrigation application is not a very well-defined market for wind turbines; further research and application tests are planned to resolve the questions. In many areas of the country the need for irrigation is seasonal; consequently, synergistic uses for the pumped water or the excess power must be found to take full advantage of the wind turbines' capabilities. Also in some areas irrigation water is obtained by pumping from deep wells. This pumping demands large amounts of power to obtain required volumes of water. Consequently, intermediate-size machines may be needed.

To resolve these unknowns, we plan to continue to support the USDA's proof-of-concept studies of wind systems in agricultural applications. Decisions regarding expansion of this work will be made when initial tests are complete. Traditionally, farms have been and should continue to be good markets for wind systems because of the isolation of application sites.

Q.14. - On page 4 of your testimony you suggest that by "judiciously selecting" to advance only the leading technologies in the photovoltaics program, you can meet your stated goals. You also suggest that your key thrust in advanced R&D is to "pick winners." Could you provide me with an indication of how this selection process works?

A.14. The advanced R&D part of the Photovoltaic Energy Systems Program supports the investigation of many materials and subsystems (technologies) for meeting the intermediate and long-range goals of the program. All these activities are reviewed on a regular basis (at least two times each year) to determine their status and the probability of each of them meeting the program goals. Those technologies that hold the greatest promise are supported by continued (and sometimes increased) funding. Those technologies that hold less promise are supported by reduced funding or eliminated from the program. Among the key factors that are used in the evaluation process are the following:

1. Attainment of a minimal energy conversion efficiency on small size (less that 1 square centimeter) samples. This efficiency must increase on a scheduled basis.

2. Attainment of a reasonable energy conversion efficiency on moderate size (greater that 2 square centimeters) samples.

3. Determination of reliability, i.e., that the devices will maintain their efficiency with a limited degradation over periods of years.

4. Preliminary cost analysis to determine whether the device can be produced at a price that will meet the long-range program goals. This includes availability of the materials for very large quantity production.

5. Detailed in-depth cost analysis to assure the program that when technically successful, the device will meet the long-range program goals.

After a technology successfully attains the above factors, it is transferred to the Technology Development part of the program for the necessary manufacturing technology development to reach commercial readiness. The transfer is not abrupt; prior to the transfer, technology development personnel are brought into the activity to effect a smooth continuation, and after transfer the advanced R&D personnel may continue some support research for the technology.

Q.14a. What attempts have you made to include small business concerns in the competition?

A.14a. Small businesses are encouraged in the advanced R&D part of the program by three means. These are:

1. Small business set-asides or objectives in formal solicitations.
2. The Innovative Concepts activity, which accepts proposals to investigate items that have promise but do not fit into our preconceived formal activities. We have found that small businesses tend to be responsive to these unbound solicitations.
3. The unsolicited proposal route. This allows small businesses (as well as others) to submit their ideas for funding at any time. If the proposal fits into either 1 or 2 above, the organization is encouraged to resubmit it on a timely basis under the appropriate solicitation. If the proposal does not fit either 1 or 2 above, it is reviewed on its own merits for consideration of funding.

At the present time, 21.7 percent of the advanced R&D funding is going to the small business community.

Q.15. Would you comment on John Deutch's recent statement that, "In solar, I believe that the 20 percent target (in 2000) is exceedingly ambitious. For prudent planning purposes, I can't get myself to believe much above 10 percent, including biomass and wind". Do you agree?

A.15. I agree that the 20 percent goal is ambitious, but I think it is achievable. The situation has changed significantly in the almost 2 years since the President initiated the Solar Domestic Policy Review: we have seen an increased public interest in solar and energy conservation; prices of conventional energy sources, particularly imported hydrocarbons, have increased dramatically; our dependence on imported oil has increased; oil and natural gas are being decontrolled and the windfall profits tax has been enacted; and our solar technology development programs have achieved real progress.

Achievement of the 20 percent goal will mean that millions of people will have to choose solar systems--ranging from active hot water, passive heating, alcohol fuels and photovoltaics for individual consumers, to large-scale industrial process heat, wind, solar thermal, ocean and hydro systems. We believe that John Deutch's statement was somewhat conservative, and that we can affect this number of decisions if we have systems that are cost-effective and reliable, if we provide consumers with the information needed to make decisions, including marginal costs, and if we provide the right incentives to get things started.

APPENDIX II

Additional statements submitted for the record.

WRITTEN STATEMENT OF GEORGE H. LAWRENCE, PRESIDENT
THE AMERICAN GAS ASSOCIATION
BEFORE
THE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE
ON THE DOE FY 1981 ENERGY R & D BUDGET
APRIL 1, 1980

Introduction

Mr. Chairman and Members of the Subcommittee:

On behalf of the American Gas Association, which represents some 300 natural gas distribution and transmission companies serving over 160 million U.S. consumers in all 50 states, I am pleased to provide you our industry's views on the Administration's proposed FY 1981 energy research and development budget.

Natural gas currently provides about 30% of U.S. energy supplies. Gas is used in about 55% of all residential and commercial establishments in the U.S., and provides about 40% of the energy consumed by U.S. industry. More gas is produced domestically than any other fuel, and gas provides three times as much end use energy to consumers as electricity.

The member companies of the A.G.A. have a vital interest in the research and development programs of the Department of Energy (DOE) aimed at developing processes and resources which will increase natural gas supplies, as well as those programs aimed at developing processes and equipment to conserve natural gas. The increasing reliance of the United States on oil imports, and the unstable events in the Middle East, continue to increase the vulnerability of our nation, and particularly U.S. industrial customers, to energy shortfalls. The A.G.A. firmly believes the gas-related programs of the DOE will make an essential contribution to developing new sources of gas supply, and new methods to conserve natural gas in order to avoid these energy shortfalls. Because natural gas is interchangeable with oil in many stationary applications, the use of natural gas in such applications can represent a potential savings to the United States of nearly 4 million barrels a day of imported oil by 1990.

A recent study, "The Least-Cost Energy Strategy", by Mr. Roger W. Sant, Director of the Energy Productivity Center of the Mellon Institute (a division of Carnegie-Mellon University), indicates that if a truly economic energy policy had been followed for the last 10-15 years, the total U.S. energy consumption in 1978 would have been 24% less (See Attachment 1). Further there would have been no loss in the amount of benefits or services derived from that energy consumption. The least-cost energy strategy hypothesizes the most economic use by the U.S. of all fuels in 1978. The study found, the use of gas for end-use services would have been 14% higher, and the use of gas for electricity generation would have been 42% lower, for a net increase of 4% in overall gas use. On the other hand, the overall use of oil would have been 30% less; the overall use of coal would have been 40% less; and the total use of purchased electricity would have dropped 43%. We believe this study emphasizes the importance of gas energy and the most economic use of all fuels.

We are particularly interested in the possibilities of the vehicular use of methane and the role DOE can play in investigating the advantages of using natural gas for fleet vehicles and other transportation uses. In comparing natural gas-fueled vehicles to three alternatives -- electric, gasoline, or diesel-fueled vehicles -- a study funded by A.G.A. found that the natural gas vehicle is very energy efficient in comparison to other vehicles, particularly when total energy usage, not just "at the vehicle" energy is analyzed.

In additon to the immediate need to reduce our nation's reliance on imported oil, future gas production must also be viewed in terms of the demand for gas energy, which will increase significantly over the short-term and the long-term. The A.G.A. estimates that the economic demand for gas - that is, the demand for gas which would exist in the absence of supply and regulatory constraints will be 25% greater by 1990 in traditional gas markets. Economic gas demand will be higher still(up 33%) in traditional markets if we are serious about curbing oil imports. Additional demand for gas will come from non-traditional markets; such as automotive fleet use, localized co-generation, and gas to promote coal use in non-attainment regions.

In view of the strong long-term economic demand for gas energy and the desirability of displacing foreign oil with gas in industrial, commercial and residential markets, the A.G.A. believes that an accelerated research, development and demonstration program should be pursued by DOE in conjunction with private industry. Many unconventional supply sources will require significant research, development and demonstration (RD&D) funding before their full potential can be realized. The A.G.A. estimates that gas from "New Technologies", such as gas from geopressured zones, gas from tight formations, methane from coal seams, gas from Devonian shales and gas from renewable land and sea biomass can potentially contribute up to 5 Tcf per year or more of gas to the nation's energy supply by the year 2000. The A.G.A. has prepared a booklet which contains a summary overview of the new technologies that could impact on both the supply and utilization of gas energy in the U.S., including recommendations as to the RD&D needed to bring them to full commercialization. (See Attachment 2.) We recommend that this booklet be reviewed in conjunction with A.G.A.'s specific program recommendations for the gas related programs of the FY 1981 DOE budget.

The importance of an aggressive gas-related R&D program to a plentiful supply of gas in the future was the subject of a workshop conducted by the Aspen Institute for Humanistic Studies. Over a five-day period in late June 1978, a group of 50 noted scientists, engineers, economists, envionmentalists, and industry leaders met in Aspen, Colorado, under the sponsorship of the Aspen Institute for

Humanistic Studies, to discuss "R&D Priorities and the Gas Energy Option." The Conference participants reached a number of very significant conclusions with broad implications for national energy policy. The group generally concluded that (1) gas energy has significant advantages over other energy forms from environmental and consumer cost standpoints, (2) natural and supplemental sources of gas energy are potentially plentiful and should continue to play a significant role in America's energy mix, and (3) a vigorous national gas-related R&D program is an equally critical factor in assuring that gas will continue to be plentiful in the future. The specific recommendations of the conference participants are outlined in the attached "Executive Summary - Workshop on R&D Priorities and the Gas Energy Option." (See Attachment 3)

We commend the Department of Energy for submitting an energy research and development budget for FY 1981 which maintains, and in some cases increases, the federal funding of research and development for several promising gas supply and utilization technologies. However, we continue to be concerned with the disproportionately small share of federal funding which gas related projects receive, when compared to other energy sources and applications, in view of the great potential contribution gas can provide to our nation's energy mix. After closely reviewing the FY 1981 budget, we estimate that gas-related projects receive only 4.2% of the total DOE FY 1981 budget. By contrast, electricity-related projects receive 35.3% of the total DOE FY 1981 budget, a ratio of almost 8 to 1 compared to gas. The Research, Development, and Applications budget reveals similar results with gas receiving 8.5% of the budget while electricity receives 77.6%, again a ratio of over 9 to 1.(See Attachment 4) This is a significantly disproportionate share when one considers that the gas industry continues to provide approximately 30% of the total energy consumed in the United States and approximately 33% of domestic U.S. energy production, and that gas demand will increase over both the short and long-term.

Recognizing the potential contribution which "New Technologies" and other non-conventional sources of gas energy can make to reducing foreign oil dependency and meeting future demand for natural gas, the A.G.A. has closely reviewed the FY 1981 DOE Budget as submitted to the Congress. Generally, the budget submission maintains adequate funding for research and development programs for several gas supply and utlization technologies. However, numerous specific gas-related programs must be closely reviewed in terms of increased federal funding in order for these projects to continue currently planned development and proceed to completion.

In this regard, A.G.A. submits the following specific program recommendations on the following programs in the FY 1981 DOE budget.

- Full funding of the request for construction and operating expenses for the high-Btu synthetic pipeline coal gas demonstration plant (Project 76-1-b). (budget authority of $56 million).

- Funding of construction and operating expenses for a second high-Btu synthetic pipeline coal gas demonstration plant (Project 77-1-b). (additional budget authority of $56 million).

- Funding of continuing design work for the HYGAS process through Phase Zero. (additional budget authority of $6.3 million).

- Funding of construction and operating expenses for the medium Btu fuel gas industrial demonstration plant consistent with the Department's announcement to fund the Memphis Light, Gas & Water division project.

- Full funding of the request for accelerating the peat gasification research program (budget authority of $13 million).

- Full funding of the request for low-Btu gasification research (budget authority of $19 million).

- Full funding of the request to continue bench scale and process development unit scale research on third generation gasification processes. (budget authority of $30 million).

- Full funding of the request for the design and technology support efforts for the Surface Coal Gasification program (budget authority of $10 million).

- Full funding of the $10 million request for the in-situ gasification research program should be authorized, as well as funding of the planned supplemental request of $10 million. Funding of an additional $10 million should not be delayed pending passage of the windfall profits tax bill, but should instead be authorized in FY 1981 (additional budget authority of $10 million, for a total of $20 million).

- Full funding of the request for the Eastern Gas Shales Project (budget authority of $12.4 million).

- Full funding of the request for the Western Gas Sands Project (budget authority of $12.4 million).

- Full funding of the request for the Methane Recovery from coalbeds project (budget authority of $5 million).

- Initiation of a program to study the feasibility, design, distribution and refueling facilities, and performance comparisons with electric vehicles, of vehicles that utilize natural gas (additional budget authorization of $500,000).

- Additional funding for the 40 KW Fuel Cell Energy program to continue procurement, installation, and field testing of prototype units (additional budget authority of $8.5 million).

- Funding for research, development, and demonstration of residential gas-fired heat pumps (a minimum of $6 million of the budget request).

- Funding of research on improved gas appliances (a minimum of $1 million of the budget request).

- Additional funding to accelerate research and development for an industrial gas heat pump program (additional budget authority of $3 million).

- Additional funding of gas/solar augmentation systems to develop economical residential and commercial application of solar-augmented systems.

- Full funding of the DOE request for the geopressured methane program (budget authorization of $36 million).

- Full funding of the DOE request for the DOE/GRI joint marine biomass program (budget authorization of $4.1 million).

- Full funding of the DOE request for projects related to gas production from land biomass in the Biomass Energy System Program.

Finally, Mr. Chairman, I would add that gas hookup moratoriums are being lifted and the residential and commercial markets for gas are expanding. In light of this trend, we urge Congress to provide funding for DOE to pursue the aggressive R&D program aimed at developing new and highly efficient gas appliances, gas heat pumps, gas utilization equipment and gas/solar augmentation systems, which I have described.

Further, we firmly believe that there is a growing trend toward greater industrial utilization of gas and that this trend will continue in the future. This is especially important if our goal to reduce foreign oil imports is to be realized. The DOE budget does not adequately address development of gas utilization equipment for industrial gas processes. We recommend DOE investigate a broader range of opportunities for development of efficient industrial gas utilization equipment than addressed in the FY 1981 Budget request.

Detailed Program Recommendations

I. Surface Coal Gasification (Energy Technology)

Introduction

For the past 21 years, the gas industry has supported coal gasification research since this technology represents a principal long-term gas supply option. More is known about the basic technology of coal gasification than any other long-term synthetic fuel or unconventional gas supply option. Since 1971 the gas industry has invested over $70 million in a joint coal gasification program with the Department of Energy and several hundred million dollars on its own commercial Lurgi scale coal gasification projects. Thus, the gas industry has a long history and future commitment to research on coal gasification. Several second-generation coal gasification processes have operated at the pilot plant scale and are now ready for demonstration as a necessary step to commercialization. Research necessary to successfully demonstrate the gasification of the highly caking Eastern coals is essential to meeting an expanding gas demand in the late 1990's and beyond. Without proven coal gasification technology, long-term financing for the gas utility industry will become increasingly difficult to acquire.

Additionally, if the Nation is to meet all of the requirements of the recent revisions of the Clean Air Act, a successful transition to coal must be partially accomplished by conversion of coal to high Btu pipeline-quality gas. The development of synthetic high-Btu gas from coal is a preferred method of substituting coal for petroleum and natural gas in many stationary uses because:

- High-Btu coal gas is the only abundant long-term domestic source of clean fuel whose full cost (including production, transportation, distribution and end-uses) we know with some certainty and for which we have technology ready for commercial demonstration.

- High-Btu coal gas requires no costly retrofitting of natural gas and oil fired equipment currently in wide use.
- The full environmental impact of substituting coal for oil and electricity, by means of producing high-Btu gas from coal at the minemouth and delivering it through an existing underground pipeline system will be less than any other method of substitution.
- High-Btu gas from coal will have a competitive advantage over coal-generated electricity for heat energy requirements.
- It is not presently economic for oil and gas customers to convert to coal. Large industrial and utility boilers, the most economical users of coal, will be finding it increasingly difficult to burn coal as a result of environmental regulations. Therefore, synthetic coal gas will be one of the most effective methods of substituting coal into the industrial marketplace.

The balanced research program in surface coal gasification that is recommended for FY 1981 has the following key elements:

A. • Full funding of the request for construction and operating expenses for the high-Btu synthetic pipeline gas demonstration plant (Project 76-1-b). (budget authority of $56 million).

- Funding of construction and operating expenses for a second high-Btu synthetic pipeline gas demonstration plant (Project 77-1-b). (additional budget authority of $56 million).

- Funding of continuing design work for the HYGAS process through Phase Zero. (additional budget authority of $6.3 million).

B. • Funding of construction and operating expenses for the Medium-Btu fuel gas industrial demonstration plant consistent with the Department's announcement to fund the Memphis Light, Gas Light & Water division project.

C. • Full funding of the request for accelerating the peat gasfication research program (budget authority of $13 million).

D. • Full funding of the request for low-Btu gasification research (budget authority of $19 million).

E. • Full funding of the request to continue bench scale and process development unit scale research on third generation gasfication processes. (budget authority of $30 million).

F. • Full Funding of the request for the design and technology support efforts for the Surface Coal Gasificaton program (budget authority of $30 million).

A. High-Btu Demonstration Plant Program - $118 million

The DOE request in FY 1981 for the high-Btu demonstration plant program consists of $56 million, of which $1 million is for operating funds to initiate environmental monitoring during construction at the selected plant site. The request for $55 million of construction funds in FY 1981 has been requested as a specific line item for the first demonstration plant (Project 76-1-b). These funds will provide for the completion of the engineering design, long lead procurement, and for the initiation of construction, including site acqusition.

The A.G.A. believes that it is also of national importance to construct a second High-Btu synthetic pipeline gas demonstration plant which will allow DOE to evaluate the different characteristics of two second generation processes which can utilize a full range of Eastern coals.

In FY 1977 Congress authorized a second high-Btu synthetic pipeline gas demonstration plant. A total of $2 million was appropriated in FY 1979 to continue funding of preliminary work on a second high-Btu demonstration plant. Further, in the FY 1980 Department of Interior and related agencies appropriations bill, the Congress agreed that DOE should use the $2 million provided in FY 1979 for project 77-1-b to continue preliminary work on a second high-Btu synthetic pipeline quality gas demonstration plant. The appropriations bill directs DOE, in selecting a process technology, to consider processes of a second generation technology that will advance the state-of-the-art. Congress also directed DOE to report to the Appropriations Committees on plans for initiating construction of a second plant prior to FY 1981. These provisions indicate Congressional support for a thorough DOE evaluation of continuation of the non-selected project, under the competition for Project (76-1-b), as a candidate in competition for a second high-Btu demonstration plant.

A.G.A. strongly recommends that Congress authorize and appropriate funds in the DOE FY 1981 budget for the second high-Btu demonstration plant and instruct DOE to proceed with the second plant. The funds will provide the flexibility and the resources required to initiate detailed engineering design and long-lead procurement to proceed to construction. We believe that approximately $56 million will be needed in construction funds for the second high-Btu demonstration plant in the FY 1981 Budget.

The HYGAS Process

The Hygas process has been under development at the Institute of Gas Technology in Chicago throughout the 70's with funding provided by the American Gas Association, Gas Research Institute, and the U.S. Department of Energy. The up to 4 ton/hour pilot plant unit has operated for extended periods of time on both Eastern and Western United States coals and a current design study for a large scale demonstration plant, funded by the United States Department of Energy, has been completed by Procon.

The A.G.A. supports an additional $6 million in budget authority to fund a Phase Zero design for a HYGAS demonstration plant.

This would give this project the option in 1982 or 1983 to apply to the Energy Security Corporation for financial incentives to proceed to construction.

The Importance of Demonstrating Second Generation High-Btu Coal Gasification Utilizing Eastern Coals.

It is important to realize that the Administration's proposed synthetic fuel production program essentially would concentrate the location of synthetic fuel plants in the Western sections of the United States, since meeting the 1.75 million barrels per day production goal by 1990 requires the immediate deployment of commercially ready technology. Those technologies that are ready for deployment and only need financial incentives to proceed to production are nearly exclusively limited to processing the oil shale deposits and the mildly caking coal deposits in the West. New technologies that can process the vast Eastern U.S. coal resources economically are under development, many of them in the Fossil Energy demonstration plant program, but are not yet ready to be commercialized. Without an accelerated program to demonstrate on a commercial scale those new technologies that can sucessfully process Eastern caking coals, the U.S. synfuels industry will be largely concentrated in the West. It is important that the synthetic fuels industry be dispersed and distributed among the various regions containing coal resources particularly the Eastern U.S. coal fields.

Successful demonstration of these advanced technologies on an accelerated schedule will lead to a national synfuels program that is broad based from both a technology and resource standpoint. This is important not only from the desirability of achieving a program that can use all of the Nation's critical coal resources, but the Eastern coal resources are located in regions that have ample and available water, the existence of a manufacturing infrastructure, the proximity to major industrial markets and an in-place delivery system.

The Lurgi gasifier has been improved significantly over the past few years and the key process steps that would be involved in a commercial scale Lurgi high-Btu coal gasification plant have been demonstrated on a scale which provides a basis for technical confidence -- using Western coal. Western coals, typically characterizd by low swelling indexes and high ash contents, are an ideal feedstock for the Lurgi process. The exit gas stream from a Lurgi gasifier using Western coals is between 30-45% methane.

Lurgi technology does not operate as well with Eastern coals, however. Several domestically-developed coal gasification processes are expected to be capable of using a full range of Eastern coals (particularly Illinois basin coals), while still operating at high efficiency. The three 'advanced' processes now being given the most active consideration are Hygas, Cogas and Slagging Lurgi.

Rationale for More Than One Plant

The three second-generation high-Btu processes currently being evaluated by DOE for demonstration are very different. Without describing the specific process of COGAS, the Slagging Gasifier and HYGAS, and comparing them with a regular dry-bottom

Lurgi process, these four processes (and other potential candidates) have important differences, which are broadly categorized as:

- Size and numbers of reactors in different sections of plant.
- Size consists of feed coal and disposition fines.
- Pressurizing feed system for coal and depressurizing discharge system for ash/char residue.
- Requirement and degree of preconditioning of caking coals (called pretreating when conducted in a separate process step) so the coal does not agglomerate and plug reactors in the gasification or other coal reaction steps.
- The actual coal gasification unit processes are different. There are moving beds, entrained combusters, moving bed with stirrer, and fluid beds.
- Gasification reactor pressures range from fairly low (50 psi) to medium pressure to high pressure (1200 psi).
- Gas scrubbing, conditioning and methanation.
- By-product treatment, especially tars and phenols.
- Co-Products. One process produces almost 50 percent of its synfuel product as a synthetic crude oil.
- Process thermal efficiency.
- Sulphur capture and conversion to saleable by-product.
- Condition of coal ash or char/ash residue.
- Plant process operability (i.e., percentage on-stream time) which affect requirements for maintgenance, spare reactors captial cost.

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Considering this array of process differences, A.G.A. believes that there is ample justification for two high-Btu coal gasification demonstration plants. The information which would be gathered through operating experience and technology verification from these two very distinct coal gasification processes will significantly enhance the development of a synfuels industry.

B. Low/Medium - Btu Fuel Gas Industrial Demonstration Plant

On Friday, February 22, 1980, the Department of Energy announced that it will participate in the coal gasification project proposed by the Memphis Light, Gas and Water Division (MLGW), a municipal utility. MLGW is the prime contractor for the medium-Btu industrial fuel gas plant to be located in Memphis Tennessee. The MGLW project was previously in competition with a second proposal by W.R. Grace and Ebasco to build a demonstration plant in order to gasify coal to produce ammonia.

The A.G.A. supports funding of construction and operating expenses for the Medium-Btu fuel gas industrial demonstration plant consistent with the Department's announcement to participate on a 50/50 cost sharing basis with the Memphis Light, Gas and Water Division project.

The MLGW project will demonstrate the feasibility of converting high sulfur bituminous coal to industrial fuel gas (IFG) with a heating value of approximately 300 BTU's per standard cubic foot. From 3,158 tons of coal per day, the plant will produce 175 million cubic feet per day, the equivalent of 50 billion Btu's or equivalent of 50 million cubic feet per day of natural gas. The Standford Research Institute (SRI) conducted a marketing study on medium-Btu gas for MLGW. The study found that a potential market exists and the utility with a reliable supply and good load factor can deliver the medium-Btu gas at the most economical price. The S.R.I. marketing study also found the proposed technology of the Memphis plant could be demonstrated in at least 78 other U.S. cities.

C. High-Btu Gasification Research

Peat Gasification Research and Development Program

1. Introduction

In July 1976, the Energy Research and Development Administration (ERDA, initiated a 2-year laboratory - process - development unit (PDU) - scale cost-shared program with Minnesota Gas Company. Tests conducted to date at the PDU-scale are very promising and have demonstrated that peat is very reactive, and is a potentially valuable resource for SNG production. Since peat is so reactive, a relatively simple single-stage reactor vessel can be used to gasify peat. Based on the laboratory test results, a preferred configuration for gasifying peat has been selected.

2. DOE FY80 Peat Gasification Program

The DOE cost-shared program was completed in July 1978. The A.G.A. recommended that $4.5 million in FY 1980 be appropriated in order to modify an existing coal gas pilot plant or construct a new pilot plant to conduct peat gasification research. The Congress appropriated $3 million in the DOE fossil budget for FY 1980.

3. Rationale for Expanded Peat Gasification Program

The United States has the second largest peat reserves in the world. In the contingous 48 state alone, recoverable energy reserves of peat exceed those of natural gas, crude oil, or lignite individually, and total about 69% quads (equivalent to 115 billion barrels of oil).

Although peat is found in all 50 states, over 90% of the reserves in the contiguous states are concentrated in 13 states: Minnesota, Michigan, Florida, Wisconsin, Louisiana, North Carolina, Maine, New York, Georgia, Indiana, Massachusetts, Virginia, and Washington. Most of these states have no other significant reserves of fossil fuels.

The preliminary PDU-scale tests conducted by IGT for the Minnesota Gas Company show that the conversion of peat to SNG is technically feasible and economically attractive.

4. Proposed FY81 Research Program - $13 million

A.G.A. strongly supports the FY 1981 budget request of $13 million to accelerate the peat gasification research program. As indicated in the DOE budget request, this funding will provide for support work in pilot plant testing, resources estimation, environmental and social-economic impact assessments, hydraulic harvesting, and for an international agreement with Finland to increase the pace of developing peat technology.

Summary

The vast peat resources located in the United States, primarily in areas that have no other major fossil energy resources and have recently experienced natural gas curtailments, demand that R&D be continued on peat gasification in FY81. This program presented above could lead to full pilot plant operations at an existing DOE pilot plant. These tests, if successful, could provide the data needed for design and construction of commercial peat gasification plants in the late 1980's or early 1990's. A.G.A. strongly supports the $13 million budget request for peat gasification research and development in FY 1981.

D. Low-Btu Gasification Research

The FY 1981 budget requests funding for three different Low-Btu gasification research projects:

1) Fixed-bed gasification - $7 million
2) Fluidized-bed gasification (pressurized) - $9 million
3) Entrained-bed gasification, atmospheric - $3 million

Each of these projects will be able to test a wide range of coals. A.G.A. supports full funding of the $19 million request in FY 1981 for low-Btu gasification research.

E. Third Generation Processes

The FY 1981 budget requests funding for three different projects related to third generation processes:

1) Hydrogasification - $11.8 million
2) Catalytic gasification pilot plant - $13.2 million
3) Process research/technology development; the Hi-Mass Flux (HMF) gasifier and the Molten Salt Gasifier - $5.0 million.

A.G.A. supports full funding of the $30 million request for research and development on third generation processes.

F. Technical Support

The FY 1981 budget requests $10 million for design and technology support for the overall Surface Coal Gasification program. The budget request indicates that in FY 1981 efforts will include engineering evaluations, equipment development, experimental projects, design studies, and environmental support analyses of a general nature rather than process specific. A.G.A. supports the $10 million budget request for design and technology support in order to accelerate critical supporting research necessary to assure successful completion of on-going designs for gasification.

II. In-Situ Coal Gasification (Energy Technology

The FY 1981 budget request centers around two major projects with funds for supporting research and capital equipment. The following amounts are requested:

1)	Western Low-Btu gasification	$6.5 million
2)	Western Medium-Btu gasification	$2.7 million
3)	Environmental Support	$0.5 million
4)	Supporting Research	$0.2 million
5)	Capital Equipment	$0.1 million

The A.G.A. supports the FY 1981 budget request of a total of $10 million for in-situ coal gasification. However, A.G.A. has several concerns with regard to the priorities within the in-situ coal gasification program. The program places an overemphasis on funding for the Western low-Btu gasification program as compared to the Western medium-Btu gasification program.

The low-Btu gas produced from this program is not as transportable as the medium-Btu gas to be produced from this program. Further within the Steeply Dipping Beds (SDB) project an overemphasis has been placed on production of natural gas with air injection (3 million Scf/ day of 135Btu/scf gas during 30 days of air injection) as compared to production with oxygen injection (1.2 million scf/day of 250 Btu/scf gas during 5 days of oxygen injection). More emphasis should be placed on testing the feasibility of production with oxygen injection that yields natural gas with a higher Btu content than with air injection.

The A.G.A. is also concerned that funding for environmental support work on in-situ coal gasification continues to drop from an FY 1979 Appropriation of $900,000, to an FY 1980 Appropriation of $600,000 to a budget request of $500,000. We believe that there are significant environmental barriers to full commercial development of in-situ coal gasification processes. The environmental support portion should be increased over the FY 1979 Appropriation of $900,000, rather than decreased, especially since in-situ synthetic production of gas may be a promissing way to develop a great portion of our domestic coal resources.

The A.G.A. notes that the Energy Trust Fund shows an additional $10.0 million for FY 1981 - for in-situ coal gasification. The Administration has indicated that if the windfall profits tax bill is passed, the Administration will submit a supplemental request including this $10.0 million. A.G.A. believes that the in-situ program is inadequate without the $10.0 million supplemental. A.G.A. recommends that the planned $10.0 million from the supplemental request should be authorized in the FY 1981 DOE R&D budget without waiting for the passage of the windfall profit tax bill. Further, authorization of the supplemental $10 million should not be upheld, pending an authorization through the proposed Synthetic Fuels Corporation.

III. Enhanced Gas Recovery (Energy Technology)

1. Introduction

The National Research Council in 1976 identified four geological sources of natural gas which are not being fully eploited. These sources are:

- Gas-bearing shales of the Eastern U.S. (Devonian Shale)
- Western tight sandstones
- Free methane present in coal seams
- Geopressured aquifiers on the Gulf Coast.

Three of these sources of supplemental gas are funded in the Fossil Energy Program. The Department of Energy Fossil Energy Program has established and developed program plans for the development of the Eastern Devonian shales, the Western tight sandstones, and methane from coal seams to establish the characteristics of these resources and develop the stimulation and production technology necessary for commercial development. These potential gas resources are so huge that, if it can be verified and developed through an expanded RD&D program over the next five to seven years, it could provide the Nation with a source of domestic energy with the potential to substantially reduce our reliance on imported oil.

Devonian shale is estimatd to contain upwards of 2,000 Tcf of gas in-place, but only about 2-10 percent of it is felt to be economically recoverable at current levels of technology. While there is some ccommercial production of gas from Devonian shale at present (over 9,000 producing wells have been drilled), such production has been limited to extraction of gas in-place, around, or below the shale formation. Improved techniques for "fracturing" the shale needs to be developed before the Devonian shale resource can be fully exploited.

While Western tight gas sands are found in many parts of the U.S., the formations with the greatest potential lie in the Rocky Mountains region of Wyoming, Colorado and Utah. Estimates of the in-place resource in the Rocky Mountains are in the 400-600 Tcf range, but the amount of gas that could be economically received is estimated at 100-200 TCF.

Methane from coalbeds occurs naturally, being held by absorption in the coal or trapped natural fractures of the coal bed. Estimated resources of coal seam methane in virgin or unmined seams range up to 700-800 Tcf.

A.G.A. wishes to highlight a recent report released by the General Accounting Office on January 10, 1980 on prospects that gas from four unconventional sources -- the eastern gas shales, Western tight gas sands, coalbed methane and methane from geopressured zones -- can contribute new supplies of natural gas. The report found that unconventional gas resources can contribute to the nation's future supply and help maintain overall production levels as supplies from conventional sources gradually decline. The reported stated "Gas from the eastern Devonian shales and western sands are the chief potential contributors to unconvential gas production in the near term. The prospects of coalbed methane will improve if further demonstrations verify that recovery is technically feasible and economically competitive."

2. Recommendation for the FY 1981 Budget for the Enanced Gas Recovery Program

The FY 1981 budget requests for the Enhanced Gas Recovery program consists principally of funding for three gas recovery programs.

1)	Eastern Gas shales	$12.4 million
2)	Western tight gas sands	$12.4 million
3)	Methane form coalbeds	$ 5.0 million

A.G.A. strongly supports the FY 1981 budget request for these three areas in order to continue the programs for assessment and recovery of these resources.

IV. Use of Natural Gas in Light Transportation Vehicles and Other Urban Transportation Uses (Conservation and Solar).

The growing number of experiments into the use of natural gas for fleet vehicles and other urban transportation uses was abruptly halted in 1973 at the beginning of natural gas curtailments. However, with the tightening of environmental regulations on car emissions and the brightening gas supply picture, a renewed technical effort directed towards alternative light vehicle technologies can again be given serious consideration. An independent study entitled "Prospects for Use of Natural Gas in Light Transportation Vehicles " found that preference for the electric car cannot be based on environmental, cost or energy efficiency grounds. The report prepared by Dr. J. Winston Porter and Dr. Morton Grosser assesses the current and expected role of natural gas as an alternative light vehicle fuel, particularly as it compares to gasoline, diesel, and electrical vehicles.

From the turn of the century to about 1950, gas-fueled engine technology found application primarily in the stationary engine market. Only in recent years, spurred primarily by air emission concerns, have gas-fueled vehicles appeared on a commercial basis. Worldwide, there are currently about 400,000 automobiles burning various gas fuels. More recently, the realization that gas-fueled vehicles may be an efficient user of increasingly expensive energy has spurred renewed interest in this type of vehicular fuel.

In comparing natural gas-fueled vehicles to three alternatives -- electric, gasoline, or diesel-fueled vehicles -- the report yielded the following preliminary conclusions:

1. The natural gas vehicle is very energy efficient in comparison to other vehicles, particularly when total energy usage, not just "at the vehicle" energy is analyzed.

2. Other "typical" performance parameters compare approximately as follows.

Automobile	Number of Passengers	Refueling Time	Approximate Range	Maximum Speed
Natural Gas				
-CNG[a]	6	5-10 mins.- "quick fill" 6-12 hrs.- "slow fill"	90 miles[c]	90 mph
-LNG[b]	6	5-10 mins.	200 " [c]	90 "
Gasoline	6	5-10 mins.	325 " [c]	90 "
Diesel	6	5-10 mins.	425 " [c]	90 "
Electric	2-4	8-12 hrs.	30-40" [c]	40-50"

3. Natural gas-fueled automobiles produce lower total air emmissions than electrical, gasoline, and diesel systems. (Total includes air emmissions resulting from energy exraction, processing/conversion, distribution, and end use.)

4. The most promising early application of methane-fueled vehicles is for local fleet service such as for taxis, buses and light truck delivery due to the lack of an infrastructure of storage and fueling stations which would be required for long-distance applications. Further, an LNG-fueled (liquefied natural gas) automobile is similar in operating range to gasoline/diesel automobiles. A CNG-fueled automobile (compressed natural gas) is usually subject to range-limitations unless cargo space is sacrificed.

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a. CNG = compressed natural gas

b. LNG = liquefied natural gas

c. Vehicle can be equipped to handle any daily range as dictated by user requirement.

2. A.G.A.'s FY 1981 Budget Recommendation for a Program on Natural Gas-Fueled Vehicles

A.G.A. urges the Congress to initiate a program within DOE to investigate the advantages of using natural gas for fleet vehicles and other transportation uses. The initial program would require approximately $500,000 in a new budget authorization. The program should concentrate future natural gas vehicle investigations on:

- Demonstration of existing dual-fired methane system in urban fleet vehicles. At least four demonstration projects should be undertaken to convert urban fleets, particularly school buses and other public transportation vehicles, to natural gas.
- More detailed comparisons of natural gas versus electric vehicles in terms of overall energy efficiencies and air pollution implications. This is particularly needed in view of the Federal Government's strong commitment to electric car R&D.
- Research and development aimed at "ground-up" design of natural gas automobiles. Since present natural gas units are conversion of gasoline cars, such R&D might well improve the natural gas cars fuel efficiency and storage characteristics (particularly fuel tank weight).
- Investigation of gas (CNG & LNG) distribution and refueling facilities needed for increased use of gas-fueled vehicles.

Detailed Program Recommendations - Conservation

V. Rationale for an Expanded Gas Conservation Program

The A.G.A. has been involved in energy conservation programs since the 1940's. These programs have evolved from the premise that energy conservation represents a significant and readily available source of gas energy, and that a cubic foot of gas conserved is just a valuable to consumers as a cubic foot of new gas found.

As a national program, gas conservation makes sense because gas supplies approximately 30% of all U.S. energy and is used in about 55% of all residences and commercial establishments (over 44 million structures). Yet, despite the predominant role of gaseous energy in our economy, A.G.A. estimates that DOE devotes only $72 million, or 6.7% of its FY 1981 conservation budget to gas-related research. We are concerned that the DOE budget does not appear to adequately fund conservation technology base research.

In response to the near-term commercialization potential of conservation technologies, the gas industry plans to request over the next 6 years total conservation funding of $217,000,000. This increased funding confirms the gas industry's strong commitment to an aggressive research program in natural gas conservation and utilization.

In light of the strong long-term economic demand for gas energy and the desirability of displacing vulnerable foreign oil with gas in industrial, commercial and residential markets, we are recommending an accelerated R&D program for gas conservation and utilizaion with particular emphasis on the following programs:

- On-site 40KW fuel cell total energy systems field test	- +$8.5 million
- Waste Energy Reduction - Industrial Gas Heat Pumps Program	- +$3.0 million

In addition to increased funding for the on-site 40KW fuel cell field testing, and the Industrial Gas Heat Pump Program, A.G.A. recommends funding in FY 1981 for continued development of residential gas-fired heat pumps, improved gas appliances, and gas/solar augmentation systems.

The GRI Program

The Gas Research Institute (GRI) has developed an Efficient Utilization Program to accelerate the implementation of higher efficiency gas-using appliances, equipment, and processes to increase the availability of affordable, environmentally acceptable gaseous fuel. The research and development (R&D) program is organized into five major subprograms, each having a separate set of objectives:

Residential and Commercial Space Conditioning: Accelerate the development and commercialization of more efficient space conditioning equipment.

Gas Appliances: Improve the efficiency of domestic and commercial gas appliances, without compromising safety and reliability.

Fuel Cell Energy Systems: Evolve fuel cell technology into operating, gas-using equipment that will be highly efficient and highly acceptable environmentally.

Industrial Utilization: Accelerate the implementation of more efficient gas consuming industrial processes and hardware in order to increase the availability of affordable and environmentally acceptable gaseous fuel for industrial processes.

Solar/Gas Energy Systems: Increase the natural gas availability by using solar energy as a supplemental energy input in a variety of thermal applications, ranging from residential/commercial space conditioning and water heating to industrial processes.

VI. Residential and Commercial Space Conditioning

1. Introduction

The largest single application of natural gas in the residential and commercial sectors is for space heating; it accounts for almost 70% of total gas sales in the two market sectors or approximately 5.3 quads.

Gas furnaces currently being produced have a maximum seasonal efficiency of 75 to 80 percernt, but many of them achieve only 60 to 70 percent because they are oversized and/or improperly installed and maintained. Although many improvements and new concepts have been identified, manufacturers are reluctant to make a large financial investment in R&D programs because of associated technical risks. Thus, many gas utility companies and GRI have focused their conservation efforts on using gas for space heating in a more efficient way.

The goal of the GRI Residential and Commercial Space Conditioning subprogram is to increase the efficiency of space conditioning sytems and thereby reduce energy requirements and costs to the consumer. Specific objectives of the subprogram are to:

- Develop gas heat pumps with COP's* ranging from 1.1 to 1.8 in heating, and 0.6 to 1.2 in cooling.
- Develop improved gas furnaces with seasonal efficiencies of up to 90 percent.
- Conduct systems analyses resulting in improved understanding of space conditioning systems.

Contractors and potential manufacturers will be heavily involved in the prototype construction and field test stages of technologies to increase the efficiency of space conditioning systems.

The Residential and Commercial Space Conditioning subprogram includes 17 R&D projects in three project areas: gas-fired heat pumps, improved gas furnaces, and building/system performance. Currently, most of the technologies and models are in the laboratory development and testing stage.

Most efforts in this subprogram are directed at developing heat pumps and improving gas furnaces. In terms of efficient use of natural gas, the gas-fired heat pump is the most promising technology available. When installed in northern climates, heat pumps could save 30-70% of present gas consumption. And if gas-fired heat pumps could be developed to provide an average coefficient of performance (COP)* of 1.2 when used for both heating and cooling, they would save approximately one-third the natural gas currently used for residential and commerical space heating alone.

Three heat pump concepts are now in laboratory testing, and a fourth developmental program on an advanced gas-fired heat pump concept will be initiated under the 1979 R&D plan. The absorption heat pump, Stirling/Rakine heat pump, Brayton/Rankine heat pump, and Rankine/Rankine heat pump, are the four major technologies being studied. The best of these four heat pump concepts will be selected for an initial commercialization phase. In addition, there will be a continuing effort to study advanced heat pump technolgoies, compare their status, and analyze their applicability for heating only market applications.

The seasonal efficiency of existing conventional gas furnaces could be increased to about 80% and that of new gas furnaces to approximately 95% with research, development, and implementation of advanced space conditioning technologies. Among several advanced furnace concepts being considered, two hold particular promise. One is a furnace based on pulse combustion technology and the other uses additional heat transfer surface and vent damper to extract heat by condensing combustion gases. The A.G.A. laboratories have developed a pulse combustion furnace that uses a novel combustion system and recovers more heat from the combustion gases. It also eliminates the need for a chimney which is the major source of heat. The steady-state efficiency has been demonstrated to be in excess of 90 percent. A furnace manufacturer is making several prototypes to test in residential buildings. In addition to research aimed at developing highly efficient new furnaces, specialized research is needed to develop or improve the efficiency of several key furnace components, including, advanced burners, improved heat exchangers, and heat pipes.

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*COP is the amount of energy supplied to the space being heated or cooled, divided by the amount of gas energy used by the heat pump.

2. Recommendation

In 1980, GRI plans to fund $7.75 million for research in this area. A.G.A. recommends that DOE fund a minimum of $6 million in FY 1981 to keep the gas-fired heat pump programs on schedule and fully funded.

VII. Gas Appliances

1. Introduction

A.G.A. estimates that 45% of all residences in the United States use natural gas for cooking, 55% of American homes have gas water heaters, while 12% of our homes use gas dryers. Given this extensive use of gas appliances, improvements in appliance efficiencies would have significant effects on natural gas conservation. For example, better equipment designs, improved technologies, and the application of new concepts would save up to 30% of the gas now used by appliances, by improving present efficiencies.

Gas is used in the commercial sector for a variety of cooking operations, as well as for water heating and clothes drying. A.G.A. estimates that 2.3 quads of natural gas is used each year for residential/commerical appliances. Because of this extensive use of natural gas, GRI has undertaken a Gas Appliances R&D program.

The goal of the Gas Appliances subprogram is to develop residential and commercial appliances that use gas more efficiently, while retaining or improving their desirable safety and reliability features. The greatest efforts will be directed at those appliances that use the largest amount of gas. The subprogram is designed to:

- Increase the efficiency of existing appliances by 30%, in response to the federally mandated 20% improvement;
- Develop advanced appliances for the residential/commercial market that can use such components as intermittent ignition devices (IID), advanced burners, and heat pipes;
- Develop integrated appliance systems that combine several appliances and use the waste heat from one appliance to supply energy to another.

In 1980, the Gas Appliance subprogram includes thirteen R&D projects in three project areas: improved gas appliances, advanced appliance technology, and integrated appliances. Currently, most of the gas appliances being developed by GRI are in the concept and design R&D state.

GRI has directed most of its efforts in the improved gas appliances areas towards developing prototypes for improved commercial cooking equipment, particularly forced convection ovens and deep fat fryers. Other energy efficient appliance systems (e.g., recuperative radiant water heaters) will be designed and tested starting in 1980.

In advanced appliance technologies, GRI has been working on the elimination of standing pilots to improve the efficiency of residential and commercial appliances. By installing electric or electronic igniters, the energy efficiency of ranges, ovens, dryers, water heaters, or fryers could be increased by as much as 30 percent.

The integrated appliance is a new concept for which only comprehensive design and feasibility study was performed by Arthur D. Little, Inc. (ADL) as part of an initial DOE effort to develop the technology. GRI's effort, which began in 1979, concentrates on developing the two most promising systems: the furnace/water heater and the range/water heater.

GRI's 1980-1984 budget for the Gas Appliance subprogram totals $14.85 million. About 55 percent will be allocated to the development of improved gas appliances and components. In 1979, most funds were directed towards appliance improvement projects, particularly advanced water heaters; funds are also allocated for developing commercial cooking equipment. Starting in 1980 GRI will give increasing emphasis to the improved gas appliances project area; at that time, the project will receive 50% of the funding for the Gas Appliances subprogram.

Most projects were initiated in 1979. Between 1979 and 1980, GRI will develop a feasible technical base, in order to provide design and test data for the construction of operating appliance prototypes and components by 1981. Extensive field testing, leading to commercialization of more efficient residential and commercial gas appliances, will be conducted during 1981.

2. Recommendations

GRI has allocated $2.7 million to these programs in 1981. A.G.A. recommends that DOE continue cost sharing of $1 million of research in this area in FY 1981. This funding level would help produce 20% more efficient residential gas range by 1982 and a 35% efficiency improvement in commercial cooking equipment in 1981.

VIII. On-Site 40KW Fuel Cell

The gas industry has had an active fuel cell energy systems program concentrating on the residential and commercial sector for over 16 years. The Team to Advance Research for Gas Energy Transportation (TARGET), a corporation formed by the industry, supported fuel cell research during that period. TARGET ended its operations in 1977 and its function was assigned to GRI.

Primary gas industry interest has focused on the use of smaller (40-100KW) fuel cells in groups of two to six to supply the total electrical and thermal needs of a building. Specificaly, these electrochemical devices can convert natural gas to electricity and readily usable heat for space conditioning and water heating with a conversion efficiency of approximately 80%. In many buildings, particularly those in the northern and northeastern areas of the nation, a fuel cell used to supply year-round electric and thermal needs for any one building has the potential to reduce the amount of gas presently used for heating alone by 30%.

The technical objectives of the Fuel Cell Energy Systems subprogram are to:

- Investigate material and component technology to reduce the cost of first generation fuel cell systems;

- Evaluate different applications, unit sizes, fuel supply options, and fuel cell types to ensure maximum conservation benefits;
- Field test the 40KW design to collect accurate data on its reliability and energy saving and economic potential;
- Investigate second and third generation fuel cells for industrial applications.

To achieve these objectives, DOE and GRI will jointly fund a project by United Technologies Corporation (UTC) to develop and test a 40KW prototype. DOE and GRI will then jointly field test approximately 50 units in various residential and commercial applications. DOE, GRI and the gas industry will also sponsor the development of second generation molten carbonate and third generation solid oxide technologies.

The Fuel Cell Energy Systems subprogram includes four R&D projects in three project areas: phosphoric acid systems, advanced fuel cell concepts, and field test activities. Efforts in this subprogram are directed at developing a prototype and field testing the first generation 40KW phosphoric acid fuel cell, in order to reduce the cost of the technology without sacrificing reliability and efficiency. Designs and laboratory tests for second and third generation fuel cells are also being developed.

Projects relating to the phosphoric acid cells are in the prototype and component testing stages. These projects include ongoing work to test components and assemble the 40KW prototype unit. Potential field test sites are being monitored to gather data.

Projects related to advanced fuel cell development are in the concept, design and study stage. These projects involve research into electrochemistry and electrochemical engineering and the subsequent development of molten carbonate and solid oxide fuel cell power units.

To keep this program on schedule and to fabricate the 40KW field test prototype units, the A.G.A. recommends DOE funding of $8,500,000 in FY 1981 to produce the prototype units for field testing and to fund the technology development work and to maintain manufacturing competition.

Within the first generation area, expenditures for engineering research will be transferred to field test support in 1980. The high level of expenditures in 1980 and 1981 can be attributed to the capital cost of the fuel cell units for the field test. In 1982, costs will be low, since the only expense will be operating and maintaining the field test units.

IX. Industrial Utilization

1. Introduction

In 1977, 38.6 percent of industrial total energy use was in the form of natural gas. This amount represented 42 percent of the total natural gas consumption in the nation and supported approximately 25,000,000 jobs. It is quite apparent that the economic viability of the industrial base in our nation is exceptionally dependent on this clean, controllable fuel.

During past years, the Department of Energy has addressed research and development for improved gas using industrial equipment with approximately $7 million in FY 1978 and $11 million in FY 1979. That is less than 50¢ for each job which is dependent on this exceptional fuel. In the FY 1981 budget submission to Congress, A.G.A. is able to identify only approximately $17 million for the improved use of natural gas in industry. There are key opportunities for substantial savings in natural gas which are not addressed with the present budget sumission from DOE where we feel that some additions of funds are warranted due to the substantial benefits which can be accrued therefrom.

The present end uses of natural gas in industry include feedstocks, process steam boilers (about 60-80 percent efficient), and direct and indirect fired process heaters (about 10-60 percent efficient). (The next page is a graph which outlines efficiencies for industrial processes.) Overall, the industrial sector could produce important gas energy savings. Needed research, development, and demonstration falls basically into three categories:

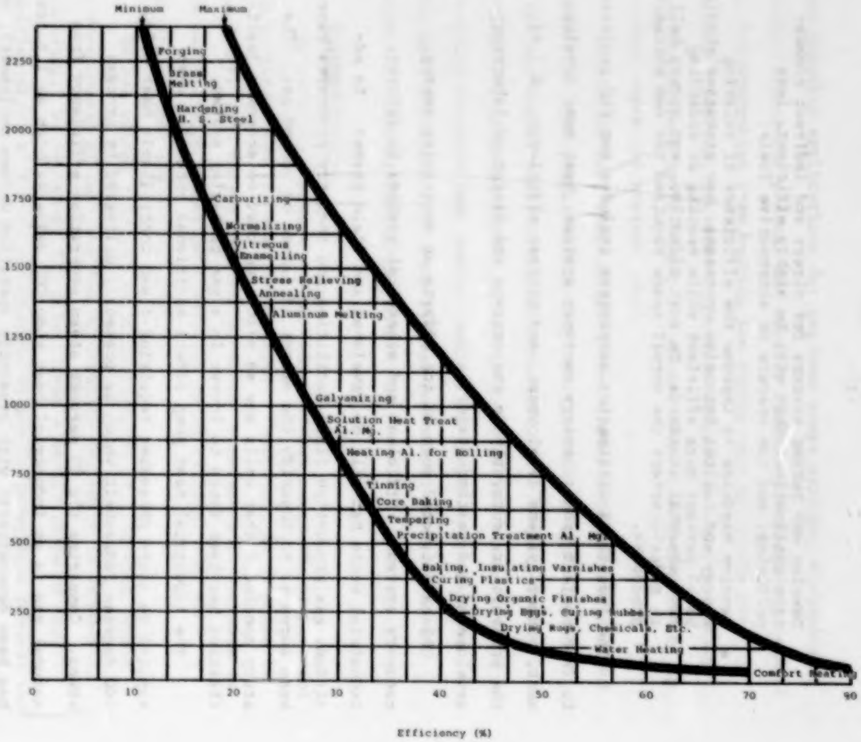
1. Improved gas-using equipment; i.e., the development of highly efficient generic classes of industrial equipment with the broadest possible number and kinds of applications;
2. Improved specific process designs, and
3. Demonstration of the efficiency, economics and reliability of new equipment and processes, which is key to industrial acceptance.

To assist industry to continue to improve the use of natural gas, GRI has undertaken the Industrial Utilization subprogram.

The goal of the Industrial Utilization subprogram is to accelerate the development and commercialization of more efficient gas-using industrial equipment and processes that will meet and possibly exceed current environmental standards. The subprogram is intended to:

- Develop highly efficient, more cost effective, generic classes of industrial heat recovery and supporting equipment with many possible applications;
- Assess the applicability of several gas-fired heat pump systems to industrial processes, and compare the economics of the heat pump system to conventional heat recovery devices;

Efficiencies for Industrial Processes



- Develop new burner systems for direct and indirect combustion applications that will be highly efficient, less polluting, and can operate on alternative fuels;
- Develop hardware to improve the efficiency of existing energy and capital intensive processes; new processes should be 50 percent more efficient while meeting or exceeding environmental standards, be cost effective, and occupy half to three-quarters the normal space required for conventional processes.

The Industrial Utilization subprogram includes ten R&D projects in four project areas: energy recovery systems, heat pump development, burner systems development, and process efficiency. All of the projects are currently in the concept and design or laboratory development and testing stages.

GRI has directed most of its efforts at developing energy recovery systems. Efficient and economical systems to recover industrial waste hat will be developed and field tested. In addition, gas production field facilities and industry processes have been surveyed to identify the extent of flared or vented gas. The study concluded that wells are so scattered that no economic justification has been found to invest in a gas gathering system.

The industrial heat pump offers additional potential when applied to those processes requiring clean controllable heat below 400 degrees Fahrenheit which is presently delivered by process steam. Comparing the 80 percent steam generation efficiency from natural gas to an industrial heat pump COP value as high as 1.8 (as has been demonstrated with presently operating German equipment), an efficiency improvement factor greater than 2 could be implemented. That is, the equipment would carry out the same process while using one-half the amount of natural gas presently required. Among the many possible applications for gas heat pumps systems, agricultural drying (especially grains) and textile finishing (which uses natural gas for everything from heating the drying vats to drying the finished textiles) are two of the most attractive and interesting. Here the systems could supply the needed heat at efficiencies of up to three times the present level.

Industrial heat pumps differ considerably from residential and commercial heat pumps in that they need to address higher temperatures and higher capacities, and therefore, must be larger and incorporate advanced fluids rather than the freons presently in operating electric heat pumps. Addressing these needs requires programs to improve heat pump fluids, mechanical equipment and establish a strong technology base.

2. Recommendations

In order to adequately fund this critical research, significant DOE participation is urgently required. Therefore, in relation to the DOE FY 1981 budget submission, A.G.A. recommends an increase in the waste energy reduction submission of $3 million. GRI is willing to cost share this program.

We are making only one recommendation in FY 1981 with regard to development of improved gas utilization equipment in industrial processes. We recommend DOE investigate a broder range of opportunities where efficient utilization of gas in industrial process can be achieved through development of improved gas utilization equipment.

X. Solar/Gas Energy Systems

1. Introduction

Solar energy is an ideal complement to natural gas in applications ranging from residential heating and cooling to industrial process heating. Solar energy is widely available, inexhaustible, and nonpolluting. Natural gas can be used to boost the thermal output of solar energy systems and to supply energy needed when direct or stored solar energy is not available.

The major barrier to the widespread use of solar/gas energy systems is the high cost of the systems and the long payback period. Most individuals and industrial firms will not accept the 15- to 20-year payback period of currently available systems. Therefore, the GRI Solar/Gas Energy Systems subprogram is directed toward making these systems more economical in the near future.

The Solar/Gas Energy Systems subprogram is designed to develop more economical solar equipment. The specific technical objectives are to:

- Develop reliable and economical solar-augmented heating and cooling systems;
- Improve solar thermal storage systems by reducing their size and overall cost;
- Develop natural-gas appliances supplemented by solar energy for the residential and commercial sectors; and
- Develop economically competitive solar energy systems that supplement natural gas in industrial processes.

All of the technologies in the Solar/Gas Energy Systems subprogram are in the concept and design R&D stage. Solar energy systems for residential and commercial applications are currently being developed. GRI's initial studies will concentrate on identifying solar technologies that are compatible with residential and commerical gas energy systems, and on identifying residential and commerical gas appliances that can be augmented by solar energy systems. The potential for industrial solar/gas energy applications, as yet largely untapped, appears high. The work in this area will begin by identifying industrial gas-using processes that can be augmented by solar energy systems.

2. Recommendation

About 70 percent of GRI's 1980-1984 Solar/Gas Energy Systems subprogram $11.4 million budget will be allocated to develop economical residential and commercial applications for solar-augmented systems. A smaller amount is to be spent on industrial applications. The contributions of GRI and government to the study of residential and commercial applications will steadily increase through 1982 and then decline slightly in 1983. Industrial contributions to this research are not expected before 1982. Funding from government, industry, and GRI for the study of industrial applications is expected to grow annually through 1983. Accordingly, A.G.A. recommends that DOE cost share the GRI work in gas/solar augmentation systems in FY 1981.

XI. Research and Development Program Directed Toward Maximizing Natural Gas Production From Geopressured Reservoirs

1. Introduction

Unconventional natural gas resources are a major energy supply option which can be brought into production in a relatively short time frame. Your subcommittee has jurisdiction over research and development funding for one of the more promising unconventional gas resources, geopressured methane gas. This potential gas resource is so huge that if it can be verified and developed through an expanded RD&D program over the next several years, it could provide the nation with a source of domestic energy with the potential to substantially reduce our reliance on imported oil. A.G.A. supports the DOE FY 1981 budget request of $36 million for the RD&D program on geopressured methane.

2. Status of DOE's Current Research and Development Program

Several recent investigations have indicated that the geopressured-geothermal acquifers of the Texas and Louisiana Gulf Coast contain vast quantities of dissolved natural gas and represent a significant source of gaseous, hydraulic, and thermal energy.

A tabulation of geopressured gas resource estimates is shown in Table 1. The wide variation of the estimates is indicative of the degree of uncertianty in resource assessment. Recovery of the gas is dependent upon the quantity and quality of the sand within the geopressured environment. Based on the wide range of recoverable resource estimates, it would appear that while an appreciable amount of gas is contained in-situ in the resource, the upper and lower bounds of the actually recoverable resource are educated guesses at this time.

TABLE 1
ESTIMATES OF NATURAL GAS IN GEOPRESSURED AQUIFERS

		Total Resource in Place (Tcf)			*Recoverable Resource (Tcf)*		
Date	*Name*	*Texas*	*La*	*Total*	*Texas*	*La*	*Total*
'75	USGS. #726			24,000			2,500
'75	LLL-Howard						222
'76	MOPPS II						500
'77	Brown (Hudson Institute)			50,000			5,000
'77	Hise (LSU)			3,000			150
'77	Dorfman (UT)			5,700	82		257
'77	Lewin Associates*	184	800	984	4	40	45
'78	Wallace (USGS)		3,200**				
'78	Bernard					14	

(Myron H. Dorfman, Director Geothermal Studies, University of Texas at Austin, "Gas Supply Review," October, 1978, Vol. 7, No. 1)

The wide variation in these estimates points out the significant uncertianties associated with the reservoir characteristics of the geopressured-geothermal resources at this time. In addition, there may be significant technical and environmental problems associated with commercial exploitation of the resource, for the most part stemming from the high water flow rates (estimated at 40,000 to 50,000 bbl per day per well) needed to yield attractive quantities of energy.

The federal government has had an active research and development program on geopressured-geothermal resources since 1975. The goal of the program is to stimulate the commercial development, by the private sector, of the geopressured-geothermal resource as an economical, reliable, safe and environmentally acceptable energy source. As indicated in the DOE budget request for 1981 the present focus of the DOE subprogram is on the acquisition of geopressured fluid production data to determine the technical factors that affect recoverability and influence costs. These data will come primarily from flow tests of geopressured wells. Two types of wells are involved in these flow tests: those being drilled by industry for oil and "free" (undissolved) gas production, and new DOE wells designed especially for geopressured reservoir testing. If successful, the program will provide the information required by industry to develop geopressured energy resources beginning in the mid-1980's.

3. Administration's Proposed FY 1981 Program

A total of $36.0 million was appropriated in FY 1980 for the geopressured-geothermal program. The administration is requesting again a total of $36 million for FY 1981 to continue the program. A.G.A. supports the DOE request for $36 million in FY 1980 for the geopressured-geothermal program.

However, A.G.A. is concerned that the planned schedule for flow testing in five existing and five new wells as outlined in the FY 1980 budget statement is modified in the FY 1981 budget request. The DOE estimates that only three new wells will be drilled in FY 1981 instead of the five originally planned. A.G.A. strongly believes that in order to obtain the necessary data and experience to adequately complete resource characterization, and evaluate its recoverability, that it will be necessary to pursue the testing of five new and five existing wells in FY 1981, as envisioned in the FY 1980 request. Adequate funds are requested in FY 1981 for DOE to conduct a ten well program designed to complete long-term production tests, as originally planned.

4. Rationale for an Expanded Program

Proposed Resource Assessment Program for Geopressured Methane Research in FY 1981

A.G.A. recommended for FY 1980 that a six to eight year accelerated program involving long-term (one to two years) production tests of up to 20 wells plus extensive supporting research be initiated. We again recommend that DOE initiate such an accelerated program in FY 1981.

Recommended Resource Assessment Program

The program commences with drulling one or two wells into the shallow portion of a geopressured gas cap and two or three wells into the deeper geopressured structures during FY 1980. As field experience and supporting research provide increased understanding the schedule of drilling wells for long-term production tests would evolve as follows:

Number of Wells to be Drilled

Fiscal Year	Geopressured Test Wells	Shallow Aquifer Test Wells
1980	3	1
1981	4	1
1982	3	1
1983	3	1
1984	2	1
1985	Continue testing of wells drilled previously.	

Extensive analysis of prior geophysical, well testing, and gas production data to deduce permeabilities and fault block areas is a prelude to selecting locations for wells to be drilled after FY 1980. Regional geophysical surveys are required to determine the locations of the extensive reservoirs necessary to assure long-term production. These reservoir parameters are of major significance to the economics of production, but for present they have been defined only for the South Texas onshore area.

Laboratory analyses of core samples to determine the rock mechanics properties relevant to subsidence and the decline in permeability as fluids are produced and to define drive mechanism and factors controlling the amount of gas entrained are essential aspects of the supporting research.

The major technical issues that must be addressed and resolved during the drilling program are:

1. The long-range/large volume hydraulic continuity in the producing formation
2. Natural gas saturation levels in the brine solutions
3. Either beneficial use or economic disposal of produced water
4. Corrosion of production equipment
5. Subsidence of the land above the aquifers
6. Size of producing reservoirs
7. Reservoir characterization and selection to maximize free gas production
8. Development and demonstratin of high volume gas/water separation systems
9. Economics of producing the methane
10. Reservoir formation damage at the well face due to high volume long-term flow rates.

Commercial feasibility will depend largely upon solution of critical problems such as the ability to predict, locate and drill reservoirs having suitable flow rates, methane content and long-term productivity to justify further development and industrial investment. These answers can only be provided by a drilling and production research program.

Environmental Research

Many environmental issues are being addresded as a part of the current geopressured geothermal program. However, substantial expansion of work directed toward minimizing the cost of environmentally acceptable water disposal is required. Specific issues to be addressed are the cost of processing required before water disposal into the Gulf of Mexico and the cost of subsurface disposal without excessive plugging of disposal wells due to solids dissolved or entrained in the water. Surface disposal methods have been considered, but the water's salinity, along with a strong possibility of levels of boron and radium in excess of the Environmental Protection Agency's standards, appears to preclude this methodology at this time. While reinjection seems to be the best disposal method, the water could be pumped into the Gulf if it meets EPA standards.

Also an expanded program in studying and evaluating the effects of subsidence on geopressured gas wells is required. This is especially important in Louisiana since many of the geopressured reservoirs underlie marsh land.

One other environmental issue is the thermal pollution effect of large volume high-flow rate hot brine production over a long period. While the environmental issues have not received as much attention as the resource assessment research, solving them is critical to commercial production.

Institutional Barriers

A major and parallel effort with the geopressured research program is required to adequately address the institutional barriers that must be solved before any significant commercial production can be achieved. Technical questions cannot be addressed in isolation. They must be placed in context with institutional problems. The resolution of these barriers is required to remove the uncertainties to the point at which private ventre capital for resource exploration would be available on a high confidence level.

The primary institutional barriers are legal remedies needed to answer:

1. Proper separation of geothermal and water rights
2. Resolution of the horizontal divestiture problem
3. Accurate legal description of the resources.

Certainly, major investments (i.e., aside from extrapolatory research programs or isolated or unique situation) will not be made in any activity where the investor is unsure as to whether he has the right to produce the resource.

It is recommended that a major program at a level of $3 million per year for three to four years be initiated by the Department of Energy to fully investigate and recommend solutions to these institutional barriers. This program should be conducted concurrently with the RD&D program. This work could be largely conducted through the universities and state agencies along the Gulf Coast. It is extremely important that this work be closely coordinated with the research program.

Program Costs

Estimated costs for each well in this accelerated program are about $0.5 million for site selection and establishing environmental acceptability prior to drilling, $4.0 million for drilling, coring and completion and $1.5 million for one year of production testing. Additional costs have been projected for addressing the environmental and institutional problems.

The attached table presents a rough estimate of the cost of a definitive evaluation program of the Gulf Coast geopressured aquifer natural gas potential. The broad outline of the program and the respective costs of the various elements are included. The essential operations are as follows:

Resource Assessment

1. It is obvious that geophysical exploration of the detail commonly praticed by the petroleum industry cannot be justified at this time; however, broad reconnaissance surveys should be made of each basin selected and detailed surveys should be performed around each well site both to assist in geologic formation characterization and to assess the abilities of the geophysical technology to contribute to resource evaluation.

2. In the selection of any test location the known parameters of the aquifer from drilled and tested wells, from any oil or as fields in the basin, etc., should be used to design the test program.

3. If the evaluation is to approach meaningful dimensions at least three wells in each of the five basins should be drilled and tested. Additionally, one well per year should be drilled in the shallower aquifers to test the potential in these structures.

a. The drilling, coring, logging and preliminary well testing for porosity, permeability, thickness, salinity, dissolved gas saturation, etc., is of first priority.

b. Well completion to permit high flow rates and to control potential sand production, corrosion, scaling is essential.

c. The major problem, of course, is long-term production testing to develop pressure-production characteristics and drainage radius of the well and volume of reservoir affected.

d. Other technologies such as performance of surface equipment, environmental problems associated with general surface handling and water disposal or reinjection must be included.

e. Major environmental considerations such as land subsidence, fault activation, earthquake, must be evaluated and extensive data collection is required.

4. Modeling - Both pre-test and post-test reservoir simulation model tests are essential to elucidating and interpreting the results of well production.

Environmental

Major environmental considerations such as land subsidence, fault activation, earthquakes as well as broad ecological problems are entailed as a major public interest assurance program. The data collected from the testing program must be fully evaluated and analyzed.

Legal

Ownership, unitization, regional impacts are symptomatic of the magnitude of legal concerns that must be resolved.

Electric Market

In connection with possible recovery of thermal energy is consideration of the interfacing of power generation facilities with established distribution systems as well as other potential uses for the thermal energy. Preliminary studies indicate that it is theoretically possible to recover about 5MW per well from the heat in the brine and up to about 0.6 MW (depending on reinjection pressure) from the hydraulic pressure of brine. Research should be conducted on these individual energy-recovery units which could be installed at each well.

Technology Transfer

If the national interest is to be served adequately wide dissemination of the nature and performance characteristics of all acquifers must be accomplished. The massive amounts of data to be compiled must be handled in readily accessible and interactive form.

Program Objective

The overall objective of this program is to establish a basis for risk capital investment decision making by private industry. In considering the above estimated costs, it should be recognized that if the initial wells are highly successful in terms of natural gas production, curtailment of the program in the fourth or fifth year may become appropriate because private industry can assume the initiative. However, if the experiments reveal that potential return on private investment is not adequate to motivate industry, the recommended program is minimal to reach a national conclusion that the resource cannot be developed in the near-term future at costs competitive with alternative energy resources.

A coordinated program that properly addresses the technical, environmental and institutional problems is required. A successful program could lead to commercial production of a vast energy resource.

XII. Marine Biomass Program

1. Introduction

In 1978 the Marine Biomass program was transferred from A.G.A. to the Gas Research Institute (GRI). This proram was started by the gas industry in 1974 in recognition that a renewable source of methane was essential to the long-range future of adequate gas supplies from domestic resources. The Marine Biomass Program has the overall objective of developing a system for the production of methane gas on a commercial scale that will provide a major contribution to the nation's gas supply. The approach utilizes the concept of providing a renewable resource, kelp grown in an ocean farm, in order to capture and store solar energy through the natural process of photosynthesis. The kelp is then converted to methane which is used to supplement the national natural gas requirement.

The kelp will be grown and cultivated in the ocean on an artificial structure with fertilizer being supplied by nutrient-rich ocean water. A current curtain surrounding the artificial structure holds the nutrient-rich water around the plants and minimizes abrasion of the plants on the farm structure. The marine farm concept has the major advantages of: making use of the ocean to provide cultivation area, thereby avoiding competition with land-based food, feed and fiber crops; utilizing the vast reservoir of nutrients that are found in the deep ocean waters rather than the energy consuming forms of commercial fertilizer; and, requiring no fresh water which is becoming increasingly limited and more expensive for land agriculture. An additional benefit of the marine biomass concept is found in the production of energy saving by-product such as animal feed supplements, and fertilizer.

Program Status

In 1979, the maintenance of an experimental kelp farm continued to be the main effort of GRI's marine biomass R&D. One of the most significant achievements has been the demonstration that adult kelp plants are self-proprogating in this environment. This development is significant because it demonstrates that planting techniques need not be labor-intensive since one adult plant can produce thousands of viable progeny. Between May, 1979, and January, 1980, many of these juvenille plants grew from less than one inch to greater than 20 feet in areas of the farm fertilized by artificial upwelling.

Research in this area is being handled by an R&D team to provide good co-ordination. Solar Energy Research Institute (SERI) is the prime contractor to GRI and DOE and has overall program management responsibility. SERI subcontracted the entire work to General Electric (RESD). The completion of the project is scheduled for 1997 at which point a prototype farm will have had its crop harvested and digested in a prototype digester for a period of at least tweo years, proving the commercial feasibility of this technology.

3. Recommendation

The FY 1980 joint program required $5,874,000 of which DOE provided $3,500,000 and GRI $2,374,000. In FY 1981, DOE requests a total of $4.1 million for the joint DOE/GRI marine biomass program. Of this amount, $3.1 million is for continuation of marine biomass production experiments conducted at the ocean-based engineering test farm, and $1.0 million is for digestor research. This level of funding is adequate to conduct the joint marine biomass project in FY 1981. A.G.A. supports the $4.1 million request for the joint marine biomass program.

4. FY 1981 Program Focus

With these accomplishments, problems and objectives in mind, the FY 1981 joint DOE/GRI program will focus on the following areas:

1. Continued operation of the existing biological test farm for kelp growth and yield experiments.
2. Performance of alternative site experiments in Gulf coast waters and Hawaiian waters.
3. Performance of kelp planting experiments using the existing biological test farm.
4. Continued gas generation experiments and design structures leading to construction of an engineering size digester in FY 1981.

In recognition of the importance of this program to the future of gas supplies, GRI has programmed $26 million of funds over the next five years to support this research. Thus, the successful conversion of biomass to a gaseous fuel could provide the basis for a perpetual gas supply that could continue to provide an economical source of energy from an "energy plantation" to the users. This would have the added benefit of making more use of the tremendous current investment of over $100 billion in the U.S. 1,000,000 mile pipeline network and thereby decreasing unit delivery.

5. Biomass Potential

Biomass, as a source of carbon for the production of fuels and specifically substitute natural gas (SNG), has several attractive features. The primary energy source -- the sun -- is inexhaustible and the source of carbon is, therefore, renewable since we are growing the fuel source. The Gas Research Institute, as well as the Department of Energy and other agencies, has studied alternate concepts for the production of biomass which could be suitable for conversion to substitute natural gas. These studies have all shown a practical upper limit of 7 to 11 quads per year of energy may be available by utilizing all of the potentially available land. The upper limit of energy potentially capable of being produced from a marine or ocean based biomass has not yet been determined but it is estimated that the potential contribution to the long-term U.S. energy supply could be equal to today's natural gas consumption or 20 quads per year. This would require a growing space equal to a square 165 to 335 miles on a side. While you would not construct a single farm this size, it does represent the total space required.

6. Summary

In summary, the GRI is aggressively supporting, in cooperation with the Department of Energy, a research program to determine the feasibility of farming the ocean for biomass to be used for the production of substitute natural gas. To keep the program on schedule will require $4,100,000 of DOE funds in FY 1981. The promise of this program is based on the following:

- Unlimited potential for growing a huge kelp resource in the ocean;
- No new scientific breakthrough required to prove the concept;
- Preliminary studies indicate gas cost could be competitive with other SNG sources;
- Renewable resources with no environmental problem.

If the technical challenges we face can be overcome, we believe an ocean system of this type can provide substantial amounts of renewable energy.

XIII. Gas from Land Biomass

1. Introduction

Natural gas can be produced from land biomass utilizing thermal decompostion or anaerobic digestion -- the biological breakdown of organic matter into methane and other materials in the absence of oxygen. Feedstock for this source of gas is agricultural waste material and land plant matter specifically grown and harvested for gas production. Plant material may include grasses, woody plants and crop residue. Because of competing uses of land and water the gas potential from land biomass is not as large as the gas potential from water-based biomass. Land biomass has an ultimate potential of 7-11 quads of energy/year if all available marginal land suitable for growing crops is utilized.

A.G.A. is interested in the potential of methane production from municipal solid waste (MSW). The operation works most efficiently in cities larger than a half million people, and it is as a supplement to municipal suppliers that gas from MSW may make its most significant contribution. A report, "Premier on Natural Gas and Methane", (November 15, 1979), by the Scientists' Institute for Public Information states that there are 65 cities this size in the U.S., and about 300 billion cubic feet of gas could be obtained annually from their solid wastes, about equal to the amount of liquified natural gas the U.S. will import from Algeria in 1979. This quantity is enough to satisfy 9% of the gas demands of the 65 cities, the majority of them in the energy deficient northeast. The Gas Research Institute projects 1980 output three times this level, with the generation of 1 trillion cubic feet of gas selling at prices up to $4.50 per Mcf.

2. DOE Programs Related to Gas from Land Biomass in FY 1981

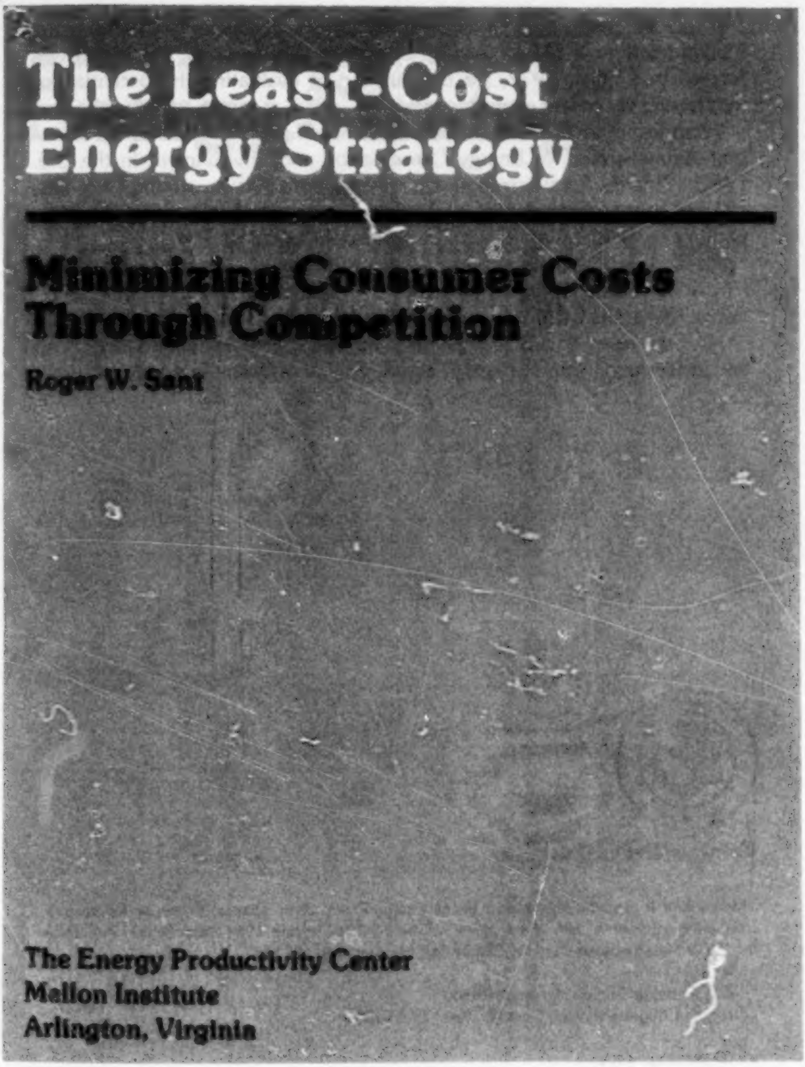
Within the Technology Support subprogram of the Biomass Energy Systems (BES) Program, the DOE will conduct programs to pursue the development and demonstration of biomass energy systems for on-farm use. The activities are focused on anaerobic digestion of farm residue, and on-farm fermentation systems for alcohol production. Current projects include: anaerobic digestion of animal manure to produce methane at a Bartow, Florida feedlot and at a small dairy farm at Cornell University.

Within the Conversion Technology subprogram, activities planned to be carried out in two areas, Biochemical Conversion Activities, Thermochemical Conversion. Anaerobic digestion and fermentation represent two processing areas under the Biochemical Conversion area. Within the Thermochemical Conversion subactivity, gasification and liquefaction conversion technologies will be investigated. This gasification produces a medium-Btu gas that can be upgraded into other energy intensive products. Construction funds for FY 1981 of $2 million will be used for a detailed design of a Gasification Experimental Facility if the FY 1980 conceptual design is favorable.

A.G.A. supports the FY 1981 request for these programs related to production of gas from land biomass.

Attachments

1. "The Least Cost Energy Strategy: Minimizing Consumer Costs Through Competition", by Roger W. Sant, Director, Energy Productivity Center of the Mellon Institute, 1979.
2. "New Technologies for Gas Energy Supply and Efficient Use", American Gas Association, April, 1979.
3. "Executive Summary -- Workshop on R&D Priorities and the Gas Energy Option", June, 1978, Aspen, Colorado.
4. "Analysis of the FY 1981 DOE Budget", American Gas Association, Febraury, 1980.



The Least-Cost Energy Strategy

Minimizing Consumer Costs Through Competition

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The Least-Cost Energy Strategy

Minimizing Consumer Costs Through Competition

Contents

INTRODUCTION 3

VARIED APPROACHES TO THE ENERGY PROBLEM 9
  Early Perceptions 9
  The "Oil Import Syndrome" 10
  Other Tactical "Diversions" 13
    Nuclear Power 13
    "Soft Paths" 14
    Solar Power 14
    Price Controls 15
    Energy/Environment Problems 16

A NEW CONTEXT AND CONSENSUS FOR ENERGY POLICY 19
  Focusing on the Economics of Energy 19
  "Conservation" and Productivity — The Post-Embargo Experience 20
  "Decoupling" Energy and Economic Growth 22

OVERALL IMPLICATIONS OF THE LEAST-COST STRATEGY 27
  1978: Comparing Two Cases 27
    Differences in Fuel Use 30
    Improvement in Energy Efficiency 30
    Overall Impact of Efficiency Improvements 35
    Capital Requirements of the Least-Cost Strategy 36
  Limitations and Opportunities of the Least-Cost Case 37
  Future Evolution of the Energy "Mix" 38
  The Value of this Least-Cost Analysis 40

CONCLUSIONS 43

FIGURE 1 — Market Shares of Various Energy Technologies....29
FIGURE 2 — Industry Market Shares of Various Energy Technologies....32
FIGURE 3 — Building Market Shares of Various Energy Technologies....33
FIGURE 4 — Transportation Market Shares of Various Energy Technologies....34
TABLE 1 — 1978 Fuel Consumption....31

ACKNOWLEDGEMENTS....47

REFERENCES....49

A Technical Appendix has been published separately and is available.

Introduction

Prior to the 1970's the supply and consumption of energy were relatively obscure matters to most people. They were, in fact, functions largely taken for granted. Within less than a decade, however, "energy" has emerged as one of the more provocative words of the times. Indeed, the 1970's may well be characterized as the decade of the "energy crisis." U.S. and world energy problems have become the themes of television commercials, the topics of classroom discussions, the subjects of intense political debates.

In keeping with its new-found notoriety, the word "energy" now tends to evoke controversy in almost every quarter. To the consumer advocate, it raises the specter of oil company "rip-offs;" to the executive in an energy industry, a stifling web of government regulation; to the environmentalist, oil-polluted shores and strip-mined lands; to the energy bureaucrat, a recalcitrant Congress unwilling to grapple with difficult issues; to the legislator, a host of seemingly irreconcilable claims from various constituencies; and to the ordinary citizen, the *fact* of soaring gasoline prices and utility bills — new demands on household budgets for which no tanglible return is seen.

Not surprisingly, much of the discussion of our energy problem has been strident and acrimonious. The results of pursuing, or failing to pursue, this or that particular course of action have been depicted in the direst terms. This atmosphere of controversy has resulted from a number of factors. Our energy problem is, of course, both real and immense, elevating conflicts among a number of very legitimate individual and national goals. Even those who regard the "energy crisis" as a hoax have not avoided the occasional scarcity and the higher costs of fuel that have occurred in recent years. Dealing with such difficulties in an open, democratic society necessarily involves controversy.

Yet, the controversy surrounding the energy problem seems to have been inordinately heightened by the divergent motivations that various parties have brought to the debate and by the limited objective of decreasing U.S. dependency on oil imports in which so much of the debate has taken place. Because this import framework has been so ineffective, we have sought to identify a broader context for the consideration of energy policy — one in which many seemingly conflicting interests become part of the solution instead of part of the problem.

The analysis that this paper is based upon suggests that a more useful framework does exist for dealing with our energy problems — one that is far broader than dependency on foreign oil — and that the ultimate goals of different parties to the debate may be more reconcilable than many of them believe.

This thesis leads us to conclude that the resolution of the energy problem might be achieved through what can be called the "least-cost strategy," a strategy that concentrates on the ultimate goal of providing individual and industrial consumers with all the heat, light, and mechanical motion — the ***end results*** of energy use — that they require, or even want, at the least possible cost.*

The conventional import context in which the energy problem has been examined concentrates on the numbers of barrels of oil that can be produced or "saved" through new production or conservation. Within this framework, the competing elements include various fuels — oil, coal, natural gas, etc., — and various methods of "saving" energy — lower speeds on the highways, colder homes in winter and warmer homes in summer, etc. But production and conservation of a given number of barrels of oil or other quantities of energy only partially addresses the function of energy in our economy and our lives. A thriving economy and a materially rewarding life are dependent not on the given quantity of energy consumed but on the ***services*** or ***benefits*** that are derived from that consumption.

In this broader context, the competing elements are far more numerous, including a host of technologies — already developed or, like most future oil reserves, awaiting discovery — which, while not producing new energy, will enable us to use energy far more efficiently. In this broader context, oil, for example, which has been protected from competition by past energy policies, would face stiff competition from new energy-efficient technologies, like those employed in the more fuel-efficient automobiles that have begun to roll off the assembly lines in recent years. This interplay among a far larger number of competing elements would maximize the benefits derived from future energy use, providing the same or greater services with less energy consumption than we have been accustomed to in the past. This enhanced competition requires an economic environment in which competition is unhindered by questionable government subsidies or artifically low prices. The creation of such an environment is essential to the implementation of the least-cost strategy.

This is hardly a radical proposition. In fact, some of the results that would occur from application of the least-cost strategy are already taking place in the natural course of events. Nevertheless, the energy debate today is still dominated, as it has been for most of the decade, by narrower and, often, more divisive themes and is still conducted within artificial limits. A least-cost strategy is synonomous with a strategy to maximize competition for energy ***services***.

In this paper we will examine some of the approaches that have been proposed for solution of the "energy crisis" and, in light of our post-embargo experience, suggest that a least-cost strategy can provide the consensus on energy policy that has been so conspicuously lacking over the past five years. Then, we will consider the implications of this strategy, in terms of demand for energy services, energy consumption and energy efficiency, by comparing two cases: our actual energy experience in 1978 and a hypothetical 1978 experience that would have resulted from an application of least-cost principles in the mid-to late-1960's when, after two decades of stable or declining energy prices, it became evident that prices would rise in the years ahead.

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* Cost in this paper means the internal economic cost of energy services (fuel, capital, and other operating costs) to the consumer over the lifetime of, for example, a house, automobile, furnace, boiler. It includes environmental and other social costs that are or will be reflected in cost because of legislation currently in force, such as the Clean Air Act. See the Technical Appendix and the footnote on page 28 for more detail of the methodology used in this analysis in establishing "cost."

Although the purpose of this analysis is to indicate the kind of changes that could have taken place and ***not*** to project with statistical accuracy actual results that could have been attained, the hypothetical case will indicate that, ***theoretically***, a least-cost strategy applied during the 10 or 12 years prior to 1978 could have reduced the cost of energy services by roughly 17 percent in 1978 with no curtailment of services. We will then cite some conclusions based on this analysis which might help us realize the chief goal of a least-cost strategy — adequate energy services at a minimum cost. In addition, we will suggest that a least-cost strategy could also resolve many concerns that have appeared to be in conflict during most of the energy debate — concerns over nuclear power, oil imports, environmental integrity and so forth.

We have concluded that implementation of a least-cost strategy would utilize much of the traditional free market system. This conclusion arises not out of the belief that "free enterprise" can provide solutions to all of our problems. Indeed, such immense problems as world poverty and hunger and the burden of an escalating arms race will not yield to simple free market economics.

Our conclusion about the value of market forces in the operation of the least-cost strategy arises from the evidence of our analysis that, in regard to most of our ***energy*** problems, a freely competitive environment would work, primarily because of the numerous, diverse and actually or potentially competitive technologies that can be brought into play in the energy economy.

Although the "energy crisis" poses immensely serious and difficult problems, the effort to solve these problems like the effort to solve most problems, offers opportunities that can be seized to our ultimate benefit. We believe that the least-cost strategy, as a positive, constructive approach to the "energy crisis," would enable us to make the most of those opportunities.

Varied Approaches To The Energy Problem

Early Perceptions

In its brief evolution from obscurity to prominence during the 1970's, the energy problem has been perceived and defined in a variety of ways. Although the constituency for doing something about energy has grown dramatically, the problem has meant different things to different people at different times.

Some of the earlier expressions of concern about energy during the 1970's arose from a philosophy that was prominently espoused in the Club of Rome's ***The Limits to Growth***, published in 1972. The dominant theme of this book stressed the ethical considerations of sustained growth. The argument was that civilization was at a critical juncture:

> Man can still choose his limits and stop when he pleases . . . The alternative is to wait until the side-effects of technology suppress growth themselves or until problems arise that have no technical solutions. At any of those points the choice of limits will be gone. Growth will be stopped by pressures that are not of human choosing, and that . . . may be very much worse than those which society might choose for itself.(1)

Thus, energy could be viewed as one of the planet's raw materials, one that was rapidly being depleted. To those who subscribed to this philosophy, energy conservation provided the last alternative "of human choosing," and it therefore constituted an ethical obligation to future generations. To the extent that energy issues were debated prior to the oil embargo of 1973-74, it was often in this ethical context.

Ironically, at this time in the early 1970's, the most notable other voices raising an alarm about our energy future came from the oil industry, which, perhaps for quite different reasons, expressed concern over declining reserves of petroleum and natural gas. For example, the National Petroleum Council, a senior industry advisory group to the Secretary of the Interior, wrote in its 1972 report:

> In more recent years, domestic fuel supply has not grown as fast as domestic energy demand. During the next three to five years, a further deterioration of the domestic energy supply position is anticipated.(2)

Thus, industry experts projected a growing gap between U.S. production and consumption.

The "establishment" remained unmoved by the shortage arguments of both the Club of Rome and the National Petroleum Council. On the extraction side, for example, an unpersuaded Congress delayed approval of the Alaskan oil pipeline until forced to act in the wake of the oil embargo; similarly, steps to slow the growth in consumption of energy were never given serious consideration; and, of course, few seriously contemplated a deliberate curtailment of economic growth as a means of limiting energy consumption.

The Arab oil embargo of 1973-74, however, transformed public apathy into panic almost overnight. Suddenly the small band of people who had been urging that more attention be directed to the looming energy problem was enlarged by millions of people unnerved or enraged by gasoline shortages and rising utility bills. Despite this newly shared concern about energy, average citizens brought a very different perception to the problem. To them the energy problem involved only temporary supply interruptions and arbitrary price increases. The solution lay in an equally temporary patriotic duty to conserve some energy by curtailing activities until the nation could outlast and overcome the capricious action of a handful of Arab countries.

Five years later, the 1979 gasoline lines were being evaluated in much the same way. Blame proliferates whether the object is the oil companies, the government or the public.

The "Oil Import Syndrome"

The difficulties created by the embargo and the public outcry over them did galvanize the government. President Nixon created the Federal Energy Office and called for a national effort to rid ourselves of reliance on oil imports:

> Let us unite in committing the resources of this nation to a major new endeavor . . . that . . . we can appropriately call "Project Independence." . . . Let us pledge that by 1980 . . . we shall be able to meet America's energy needs from America's own energy resources.[3]

Experts drawn into FEO and its successor agency, the Federal Energy Administration, launched an exhaustive analysis of the energy problems confronting the nation, and a year after the embargo FEA issued its "Project Independence Report." That report did not, however, lay out a plan for energy independence; rather it demonstrated that it would be impossible to achieve President Nixon's goal within a decade, much less by 1980.

Nevertheless, policymakers at FEA (including the author) and, indeed, most observers everywhere continued to advocate a basic energy policy that would minimize what we perceived as the fundamental problem — U.S. dependency on oil imports.

Interestingly, the difficulties of treating imports as the key to the energy problem were spelled out in the "Project Independence Report":

> If the objective of long-term energy policy were simply to reduce imports, then the strategy . . . would indeed be very simple to set forth. Unfortunately, the reduction of imports, if it means substitution of more expensive domestic energy sources, could very easily be accomplished by higher domestic energy prices, inflation, a drop in real Gross National Product, supply risks, and a number of other undesireable effects such as environmental degradation, and depletion of reserves.[4]

This insight — that there were much broader considerations than merely reducing imports — led to a suggested modification of the energy objective:

> Rather than reducing imports *per se*, our objective should be to reduce our vulnerability to disruptions of imports.(5)

This new objective — reduction of vulnerability to disruptions of imports — became a feature of U.S. energy policy in the form of the Strategic Petroleum Reserve, designed to enable the nation to survive a relatively short-term embargo or other interruption in the supply of foreign oil. This distinction between ***reliance on imports*** and ***vulnerability to disruptions*** in the supply of those imports, though it improved upon earlier formulations of the problem, did not lead us to the next obvious question: whether either condition really constituted our fundamental problem.

Subsequent statements of policy during President Ford's administration continued to stress the oil import reduction theme. In his 1975 pre-State of the Union address, which was devoted almost entirely to energy, he said:

> This plan requires personal sacrifice. But, if all pitch in, we will meet our goal of reducing foreign oil imports by one million barrels a day by the end of the year and by two million barrels before the end of 1977.(6)

And FEA, in 1976, described its updated "National Energy Outlook" as "another look at America's ability to achieve energy independence."(7)

President Carter, too, after a campaign that involved strong criticism of the Ford energy program, maintained this same basic thrust. In the "National Energy Plan" of 1977 the new administration stated its energy objectives in almost the same language as its predecessor:

> — As an immediate objective that will become even more important in the future, to reduce dependence on foreign oil and vulnerability to supply interruptions.
>
> — In the medium term, to keep U.S. imports sufficiently low to weather the period when world oil production approaches its capacity limitations.(8)

Thus, the overriding problem continued to be perceived as dependency on imports.

Another objective was stated which did suggest that, ultimately, the problem would involve solutions far beyond the oil import question:

> — In the long term, to have renewable and essentially inexhaustible sources of energy for sustained economic growth.(9)

In fact, the "National Energy Plan" observed that "the U.S. and the world are at an early stage of energy transition . . . The latest transition springs from the need to adjust to scarcity and higher prices."(10) And the "Plan" made other thoughtful observations about the evolution of the world's energy situation twenty and thirty years hence.

Yet, in terms of effective government policy, the stated goal was then and is now much the same as it had been since the embargo. In a major address to the nation on July 15, 1979, President Carter said:

> I am tonight setting a clear goal for the energy policy of the United States. Beginning this moment this nation will never use more foreign oil than we did in 1977 — never.(11)

Of course, this preoccupation with reliance on oil imports during the five years of the "energy crisis" is understandable. Despite a brief downturn in imports in the immediate wake of the embargo and a slight reduction in 1978, U.S. imports have risen inexorably. The increased volume of imports, combined with the higher cost of oil in the world market, has contributed greatly to inflationary pressures and balance-of-payment deficits.

Yet, while the United States was preoccupied with reducing oil imports, West Germany and Japan, with the second and third largest non-communist economies, adopted an entirely different strategy. With aggressive export policies, they accommodated higher oil prices without hiding them with price controls, sustained economic growth, albeit at somewhat lower levels than in the United States, and achieved large balance-of-trade surpluses.* They did so despite the fact that they have a far greater relative dependency on imported oil than has the United States.** This is not to ignore the fact that the $45 billion that the United States paid for imported oil in 1978 is a huge sum. But, while that amount constitutes 1.8 percent of the U.S. GNP, the cost of imported oil to West Germany and Japan constituted 2.5 percent and 2.8 percent of their respective GNPs.(13)

To a far greater degree than the United States, those countries which have most successfully minimized the adverse effects of the "energy crisis" have treated it as a problem of adjusting to higher prices and increasing exports, rather than as one of eliminating oil imports.

Such comparisons gloss over numerous important distinctions, the most important being that these other countries may be solving their own oil problems at U.S. expense, earning dollars here to pay for their oil. It is also significant that the United States, unlike our industrialized allies, is experiencing a major decline in domestic oil production, due to depletion of our reserves, and consequently must import relatively more energy to sustain economic growth.

Yet, the comparisons do raise basic questions: In focusing on oil imports as the heart of the "energy crisis," has the United States under three presidents really addressed the right problem? Doesn't reduction of oil imports, as a solution to our energy problem, constitute a somewhat narrow tactical response to what is a far broader, strategic challenge?

Of course, dependency on imports poses serious problems for the United States. For some of these problems, such as a temporary interruption in import supplies, there are potential solutions. The Strategic Petroleum Reserve should help to alleviate future difficulties like those experienced during the embargo of 1973-74 and the shut-down of the Iranian oil fields in early 1979.

But for the larger problems there may be no solutions, or at least no energy solutions. If, for example, a major, permanent military or political change in the Middle East were to substantially curtail exports to the industrialized Western nations for an indefinite period of time, the results could be devastating — regardless of the degree of U.S. dependency. After all, most of our allies in Europe and the Far East have no alternative to continued dependence on Middle Eastern oil imports for decades to come. Indefinite curtailment of those imports would wreak havoc with their economies, and, due to our economic interdependence with them, the effects would quite quickly be felt in the U.S. economy, even if we were virtually self-sufficient in energy.

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* In 1978, the combined trade surplus of Germany and Japan was $39 billion, $5 billion more than the U.S. deficit of $34 billion.

** In 1976, 21.0% of U.S. energy demand was satisfied by imported oil, while comparable figures for West Germany and Japan were 72.2% and 95.4% respectively.(12)

Only in a superficial sense are these "energy" problems. The basic questions that they pose involve national security, and the answers to those questions depend far more on political and military than on energy considerations. Import dependency, then, is not the best overall framework for analysis of the energy problem, although it still dominates the energy debate.

In fact, as our hypothetical case will show, application of least-cost principles during the preceding decade, might have resulted in a substantially lower level of U.S. imports than we actually experienced in 1978 and, consequently, a substantially smaller drain on our financial resources.* A least-cost strategy during that period would have heightened the competitiveness of other fuels and of energy-using technologies and made imported oil — especially at post-embargo prices — economically unattractive. Nevertheless, major government initiatives since the embargo, such as mandatory requirements that industry convert from use of oil and natural gas to use of coal, price controls on oil and gas and, more recently, proposals for massive synthetic fuel programs, have not been based on least-cost principles and, quite possibly, have resulted in higher costs than the imported oil payments we would otherwise have experienced.

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* A lower level of U.S. imports would have had substantial beneficial effects on other countries and the world economy, as well. As the world's largest importer of oil during the 1970's, the United States has provided much of the demand that has enabled OPEC to act effectively in limiting production levels and raising prices. Thus, the United States has aggravated worldwide problems of inflation and curtailed economic growth, contributing to the economic difficulties of our industrialized allies and to the staggering economic burdens of the oil-importing developing nations. The higher oil prices that U.S. demand has supported have resulted in massive transfers of cash to a number of oil producers who have not been in a position to invest it productively, resulting in reduced world economic productivity

Other Tactical "Diversions"

Our preoccupation with oil imports has been accompanied by other issues which, though relevant no doubt to the overall energy problem, have tended quite often to turn the energy debate into somewhat narrow and sometimes unrewarding channels. Consideration of these issues, too often, has become polarized and has assumed an ideological, even evangelical tone. Nevertheless, as in the case of our preoccupation with oil imports, discussion of these issues has frequently added a dimension to our appreciation of the overall problem.

Nuclear Power

The debate over nuclear power, for example, has exposed major deficiencies of policy in this area. On the one hand, eagerness to build nuclear power plants has not been accompanied by equal enthusiasm for ensuring adequate safeguards, as the reactor accident at Three Mile Island in Pennsylvania dramatically demonstrated in the spring of 1979. On the other hand, eagerness to halt all nuclear development has transformed what should be straight-forward regulatory proceedings into procedural gambits that unnecessarily make the decision-making process in the United States three to four times more lengthy than those in other developed countries. In both instances, defects of policy have been revealed.

But the nuclear debate as a whole has centered on the "goodness" or "badness" of nuclear power. Its advocates claim that it is the only remaining option; its opponents urge that its risks can never be made acceptable. Thus, the nuclear debate, as conducted thus far, has largely led us into bywaters of controversy that promise little advancement toward solution of the overall energy problem.

"Soft Paths"

A similar, though less extreme, diversion has resulted from consideration of "appropriate technology" or "soft energy paths." This approach suggests that large centralized technologies such as nuclear power plants are out of touch with the real needs of people and have moved far beyond the economic benefits that large-scale facilities sometimes provide. Instead, they suggest that we should emphasize small-scale, or "soft," technologies that more appropriately match energy production and delivery to the service needs of consumers. Articulate advocates of this approach, such as Amory Lovins and B.F. Shumacher, have greatly broadened our perspective of the ways in which our energy services might be provided by unconventional methods. Their work has expanded the role for technologies that can provide benefits that would otherwise require additional energy consumption, making the case that "soft" technologies might provide, at lower cost, the same end-services as "hard" technologies.

Still, advocates, some intentionally*, have left the impression with a great many people that the "soft path" is the only morally acceptable path because it would decentralize energy decision-making, making it independent of uncaring corporate monoliths. Their critics, in turn, deride the "soft path" advocates as unworldly proponents of a back-to-the-farm movement, who would turn the clock back to pre-industrial days.

Solar Power

Arguments, pro and con, in regard to solar power have reflected similar characteristics. Advocates of solar power have brought widespread recognition to the fact that some limited applications of solar technology are economically feasible today and a number of other solar technologies may some day provide all the energy that we need. "Sun Day," a national public demonstration for solar energy in 1978, and similar public demonstrations have heightened interest in moving towards those technologies with greater speed.

Yet, again, the debate on solar energy has taken on strong moral overtones. The Solar Lobby, in establishing an objective that solar energy should meet 25 percent of the nation's energy needs by the year 2000, and the Carter Administration, in setting a 20 percent goal by the year 2000, apparently assume that there is something inherently "good" in achieving those goals. Although the Lobby argues the economic benefits of its goal *vis a vis* synthetic gas and nuclear-powered electricity, it makes no claims in regard to other options such as efficiency improvements, nor does it assert that its goal would result in lower costs to consumers. No one today can accurately predict the cost implications of achieving a 20 or 25 percent solar share of the energy services market by the year 2000, but given current understanding of solar technology, our analysis indicates that it might be a very costly option indeed compared to conservation. Thus, we are left to conclude that, although the Solar Lobby's goal may not lead consumers along the most economically attractive path, it would lead them along a path that is somehow virtuous in its own right.

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* There is a significant difference between Lovins' arguments and those of Barry Commoner and Ralph Nader in this regard.

Debates in each of these areas — nuclear power, "soft technologies" and solar power — have made some positive contribution to the overall consideration of the energy problem. At the same time they have often tended to become intensely narrow, exclusive and divisive, diverting us from building a consensus to focus on the opportunity at hand: namely, the opportunity to effect a transition in the economy that would supply energy services in abundance at a cost that we could afford in a variety of competitive ways.

Application of least-cost principles beginning in the mid-1960's would have substantially affected each of these areas. For example, the hidden costs of nuclear power (which result from federal tax subsidies and "rolling in" the costs of new generating capacity with the far smaller costs of existing capacity) would have become apparent; nuclear power would have been seen as less economically competitive, and our reliance on it would have been reduced. In the case of "soft technologies," a least-cost strategy would have made more of such technologies economically viable at earlier times, and they would today be making a greater contribution in satisfying the nation's needs. (In fact, analysis for our hypothetical 1978 case reveals that many "soft technologies" are, or would be, competitive under a least-cost strategy.) Similarly, a least-cost strategy would have clarified much earlier the technical and economic potential of various solar energy technologies. Thus, a least-cost strategy would have fostered the natural development of each technology within its realistic scope and permitted each to assume its appropriate position in our overall energy "mix" with less controversy and diversion.

Price Controls

Another diversion that has hampered development of that consensus, probably more severely and with fewer beneficial side-effects than the debates mentioned above, has concerned "protection" of consumers through controlled energy prices. In this case the "diversion" can more accurately be called a roadblock. Ironically such "protection" — suppression of prices — during the 1970's is likely to result in higher energy service costs to consumers in the future. Suppression of prices of conventional energy — domestic oil, natural gas and electricity —has simply insulated those conventional sources from healthy competition —competition that exists in abundance at their present replacement costs. Such price suppression has placed at a competitive disadvantage both new energy-source applications, such as solar water heating, and many energy-efficiency applications, ranging from cogeneration and recuperators to storm windows and insulation. Thus, consumers have not found these alternatives economically attractive, and their penetration into the market has been slowed considerably. The irony of a price ceiling is compounded by the fact that many of its strongest advocates are those who most roundly denounce other anti-competitive practices in the energy marketplace.

A least-cost strategy would recognize that price controls buy only short-term economic benefit and that, ultimately, they mean higher costs to consumers. Applied since the 1960's, such a strategy would have resulted in significantly lower prices for energy services than those we are paying today.

Energy/Environment Problems

A final diversion that should be mentioned before proceeding involves the energy-environment dichotomy. If the passions aroused in consideration of energy-environment conflicts are as intense as those evoked by the question of price controls, there is considerably more substance in the former debate than in the latter.

In fact, "diversion" is an inappropriate term for much of the energy-environment debate. Very real questions of national goals are involved: the importance of clean air, clean water, endangered species, wilderness lands and so forth must be determined relative to other goals. Much attention has been paid to this area of concern over the past dozen years, considerable legislative initiatives have been taken and the costs of these environmental programs are now reflected in fuel prices — legitimately part of the "least-cost" calculation.

There is, however, an ancillary diversion. Denis Hayes, in ***Pollution: The Neglected Dimension***, has recently brought to our attention in a very useful way a number of environmental questions, such as carbon dioxide (CO_2) build-up, that are yet to be resolved.(14) This valuable treatise discusses some problems that may be technically very difficult to solve. But it is not at all clear that perception of such problems should justify a requirement that would prematurely force the nation on to a more costly energy course. The sorting-out of environmental priorities is an on-going process, and it is in that process that contributions like Hayes' are essential. But to attempt to anticipate public resolution of these issues in our energy strategy would be unsound, if not paralyzing. Environmental safeguards exist, more will be adopted and some will be changed. Our energy market must be adjusted accordingly, but it cannot be left in limbo.

Beyond the legislation of new environmental safeguards, our analysis indicates that a least-cost strategy would help to alleviate environmental concerns in several major areas — the production and burning of fossil fuels and the use of nuclear power. In fact, pursuit of such a strategy since the 1960's would have substantially reduced our dependence on both fossil fuels and nuclear power. Indeed, such a strategy would appear likely to mitigate a number of the long-range problems cited by Hayes.

A New Context And Consensus For Energy Policy

The preoccupation of government policy-makers with these narrowly focused problems, especially dependency on imported oil, may miss the larger point of the "energy crisis." More and more analyses, based on an increasingly detailed understanding of the world energy situation, indicate that, although these issues are highly significant aspects of the energy problem, they hardly provide the best framework for consideration of the energy problem as a whole.

In any event, the conditions causing these debates are real. For instance if the price of imported oil is "arbitrary" relative to the cost of its extraction, it nevertheless reflects the cost reality of possible alternatives. The energy problem then, is to respond constructively and effectively to these facts of life, not to wish them away. Perhaps because of our past self-sufficiency in energy and our history of low energy prices, the United States has found it difficult to adjust to these facts of life — far more difficult than other industrialized nations, which have depended upon imports and paid higher prices for their energy for many years.

Focusing On The Economics Of Energy

The basis for creation of a national consensus on energy policy, which has eluded us throughout the "energy crisis," is indicated with deceptive simplicity in the myriad public opinion polls that have been conducted over the past five years. The single most consistent and deep-seated public perception of the energy problem is that it is one of high prices and costs. This is hardly surprising with consumer energy bills almost twice as high as they were ten years ago. If the public has been confused about many features of the "energy crisis," in its perception of prices and costs it may always have been closer to the truth than its leaders. And it is important to note that the prices and costs which concern the public are not those paid for a barrel of crude on the spot market in Rotterdam; they are, rather, the prices and costs incurred, for example, in heating their homes. They are, quite rightly, concerned about the prices and availability of the ***benefits*** that they derive from energy, not about the prices and costs of raw energy itself.

Aside from that common theme, the public opinion polls present a bewildering array of viewpoints. At times the public has indicated a willingness to save energy; at times it has not. At times it has indicated a willingness to alter its lifestyle; at times it has not. It has variously blamed the oil companies, the Arabs and the government for the nation's energy problems. It has concurred in the need to cut back on energy consumption, and it has expressed doubt that a shortage exists. But regardless of those seemingly contradictory concerns, the reality of high prices unifies us all.

Other motivations for development of a workable energy policy, such as the risks of dependency on imports, the fear of depleting natural resources, the desirability of diversified energy delivery systems, the attraction of clean inexhaustible new sources and the need to preserve environmental integrity, do retain validity, of course. But the public motivation that is by far the broadest and most durable is the attraction of economically accessible energy services, which is the objective of the least-cost strategy. And, as we have noted, such a strategy, while achieving its primary goal of minimizing the costs of energy services, at the same time would provide many other benefits.

While the polls indicate that a vast majority of Americans might coalesce around a least-cost strategy, many of their leaders remain aloof. For example, the Secretary of Energy argued in early 1979 that Alaskan natural gas must be extracted and transported to the lower 48 states in preference to Mexican gas because the Alaskan product is a domestic resource and its use would lessen our dependency on imports — despite the fact that its cost would be roughly twice that of Mexican gas.

At that same time, the Secretary of Transportation called for development of a 50-mile-per-gallon automobile because of the "stark fact that we are running out of what motor vehicles run on." But if consumers refuse to buy vehicles with less seating space, it is not yet certain that the increased consumer costs of the 27.5-mile-per-gallon car already mandated will be wholly offset by reduced gasoline bills. Therefore, it is certainly questionable whether the ultimate costs to the consumer of developing and producing a 50-mile-per-gallon car with equal seating would be less than the cost of developing and using alternate fuels such as shale oil, coal liquids and biomass products.

And, finally, some members of Congress argue strongly for new antitrust measures to increase competition in the oil industry and thus to lower consumer costs, yet, at the same time, they denounce efforts to remove price controls from domestic oil — price controls which, as mentioned earlier, stifle competition from, for example, conservation and solar technologies and thus propel us toward unnecessarily high future consumer costs.

In each of these examples, the provision of energy services to the consumer at the least cost is clearly not at the top of the official's agenda. And, clearly, to that extent these officials stand apart from the consensus that awaits a least-cost strategy. Just as the American people have clearly indicated their preference for a policy that would focus on the economics of energy and provide reliable energy services at the most reasonable cost, evidence has accumulated since the embargo suggesting that such a policy is quite feasible.

"Conservation" And Productivity — The Post Embargo Experience

The shortages and higher prices that arrived with the embargo of 1973-74 and the gasoline lines of 1979 inspired, among other things, a great appreciation of the need for energy conservation. The originally perceived form of conservation, of course, was simply, "doing without." And, because of altruistic motives of stewardship and economic self-interest, a number of consumers have, in fact, curtailed some of their energy use: they have turned down thermostats, bought smaller and less comfortable cars, made fewer trips at slower speeds and joined car pools, to name just a few examples. However, the history of the post-embargo period indicates that, in the absence of a dramatic emergency, altruism wanes and that further economic incentive to forego substantial benefits of energy use is limited at prevailing prices. Furthermore, in the commercial and industrial sectors, simply "doing without" carries with it the burden of curtailed production and reduced employment opportunities. Unfortunately, this "doing without" type of conservation is the major type of conservation still being promoted by President Carter.

More palatable conservation — defined as more efficient use of energy rather than "doing without" — has been achieved through improved management of energy systems. Results in industry have been striking: many companies have found that better management can reduce energy requirements by 10 to 30 percent without major capital investments or reduced production. Similarly, the federal government reduced its energy use from 1973 to 1976 by more than 30 percent without replacing old equipment or substituting new devices, but simply by eliminating unnecessary lights, turning lights out after hours and properly adjusting thermostats. Large opportunities undoubtedly remain for further energy savings through this mode of conservation.

In the longer term, the greatest opportunities and results in conservation will involve "substitution," the use of more energy-efficient systems and processes to provide the same energy services or benefits at lower levels of raw energy consumption.

Energy in its primary forms, such as oil, natural gas, coal, solar energy and uranium, and in its carrier forms, such as electricity, must be distinguished from energy services, that is, the functions that energy provides, such as heating, cooling, lighting, and mechanical motion. Energy services, of course, are closely linked to maintenance of personal standards of living and general economic activity: homes must be heated to certain minimum levels, trucks and automobiles must be propelled and steel must be processed, for example. Yet each of these services can be performed with less energy by substituting more energy-efficient technologies than those currently in use. This fact has become increasingly clear since the embargo; higher energy prices have provided the incentive for application of such technologies. In addition, greater attention is now being focused on differences in the "quality" of energy. Higher temperature energy — a 2000°F BTU as opposed to a 200°F BTU — has higher "quality" in that it can perform a greater range of services — for example, melting steel as well as boiling water. Energy efficiency can be improved by matching the "quality" of energy consumed with the specific service to be performed.

There are hundreds of possible applications for these principles. In the case of home heating, an electric heat pump can be substituted for direct electric heating, providing the same room temperature but using 50 percent less electricity. In some instances it may be less costly to substitute a gas furnace or gas heat pump for direct electric heat. A better designed automobile can be substituted for a less efficient model, providing the same interior comfort and the same number of passenger miles but using 30 to 50 percent less gasoline. A recuperator can be attached to a steel heat-treating furnace, which, by recycling some remaining available heat in the exhaust, can reduce energy requirements by 15 percent or more.

The conclusion is apparent: a given energy service can usually be provided by substituting other systems or equipment for some of the energy being consumed. Thus, energy-efficient technologies become analogous to energy sources in the performance of given energy services. And, thus, such technologies become competitors in the energy services marketplace, helping to deliver the benefits of energy use at the lowest cost.

The potential for this form of energy conservation — or, more appropriately, energy ***productivity*** — was not appreciated at the outset of the "energy crisis."

"Decoupling" Energy and Economic Growth

In the immediate wake of the embargo, it was widely assumed that meaningful energy conservation was primarily a matter of "doing without." Conserving energy, it was generally felt, required "sacrifice." Thus the Chase Manhattan Bank stated in 1972:

> An analysis of the uses of energy reveals little scope for major reductions without harm to the nation's economy and its standard of living . . . . There are some minor uses of energy that could be regarded as strictly non-essential — but their elimination would not permit any significant savings.(15)

Interestingly, a similar conclusion was suggested in ***The Limits to Growth***, when its authors observed that "counterpressures to weaken the thrusts of growth will probably not be pleasant and will certainly involve profound changes in the social and economic structures that have been deeply impressed into human culture by centuries of growth."(16) The authors of these two statements may have disagreed on what should be done about the "energy crisis," but they were agreed that energy conservation would involve fundamental social and economic adjustments. President Carter continued that theme in his nationwide address in July, 1979:

> I am asking you for your good and your nation's security to take no unnecessary trips, to use carpools or public transportation wherever you can, to park your car one extra day per week, to obey the speed limit and to set your thermostats to save fuel.(17)

More recently, evidence has appeared suggesting that all three views — those of the Chase Manhattan Bank, The Limits to Growth and President Carter — may be pessimistic. It now appears that, despite our sense of confusion, a fundamental change has taken place since the embargo — largely due to the higher costs of energy. Fortunately, the nature of the change has less to do with sacrificed standards of living than with increased efficiency in energy use.

In 1973, for each dollar* of GNP we consumed 63,000 BTU's of energy. In 1978 — just five years later — for each dollar of GNP, we consumed 56,000 BTU's, a decline of more than 10 percent.(18) In other words, we were sustaining an equivalent level of economic productivity with 10 percent less energy. It is too early to predict to what extent this recent trend will continue because the 1978 ratio of BTU-consumption to dollars-of-GNP was at the lowest level of our historic experience.

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* 1972 dollars

Nevertheless, there are positive signs that we have seen only the beginning of significant improvement in energy productivity. For example, during the twenty years preceding the embargo, growth in energy consumption and growth in economic activity were, on average, parallel; a four percent growth in the economy required a four percent increase in energy use. Today, however, additional economic activity can be sustained with roughly one-half of the energy consumption that was required in the past. Today, an increase of four percent in GNP requires an increase of only two percent in energy use. In fact, since the embargo more than half the energy we have needed for economic growth has come from increased efficiency.

Other developments, in specific sectors of the economy, suggest that this overall improvement in energy productivity may presage further improvement, or, at least, the opportunity for further improvement.

Improved efficiency in the industrial sector has dramatically exceeded most people's expectations. During the five-year period 1973-78, industrial output in goods and services rose 12 percent, while industrial use of energy ***dropped*** by more than 10 percent — roughly a 22 percent overall improvement in energy productivity.(19) This trend has accelerated in 1979. As a consequence, industry's share of total U.S. energy consumption has declined from 40 to 36 percent, and its 1978 energy bill was $15 billion less than it would have been at 1973 levels of energy efficiency.

The buildings sector provides substantially less overall improvement (2.0 percent), but some interesting signs. For instance, according to the American Gas Association, gas space-heating requirements in 1977, per customer per degree day, were about 13 percent less than the average for 1967-1972.(20) A recent informal survey of 40 gas utilities shows that they expect an average improvement of 1.5 percent in building energy efficiency in each of the next 10 years.(21) Also, new residential and commercial structures are being built with much higher design efficiencies, according to a survey conducted by the American Institute of Architects (AIA) Research Corporation. Although comparable data are not available for pre-embargo times, the AIA believes current designs are at least 20 percent more energy efficient than existing buildings and that 35 to 50 percent improvements will soon be routine.(22)

In the transportation sector there have also been encouraging developments. 1978-model automobiles averaged 19.6 miles per gallon, according to the Oak Ridge National Laboratory (ORNL).(23) This represents a 44 percent improvement over the 1973 fleet average of 13.6 MPG. Thus, it appears that the opportunity for greater automobile efficiency is being realized, although full results will only become apparent as the older fleet is replaced by newer models. Remaining challenges include improving traffic systems, finding a better match of vehicle with trip purpose and achieving higher freight load factors.

Most of the improvements that have occurred in these sectors are attributable to the economic incentives provided by higher energy prices since the embargo and to several voluntary and mandatory government programs, such as voluntary industrial conservation goals (including mandatory reporting requirements for the nation's largest companies), voluntary appliance efficiency standards and mandatory efficiency standards for new automobiles. Recent further increases in energy prices and other government programs, such as voluntary efficiency standards for new buildings and conservation tax credits, will foster even more improvements in these sectors.

So, contrary to what we believed a few years ago, dramatic improvements in energy productivity *have* begun to occur, and, as a result, the costs of services have been reduced from what they would otherwise have been. We may be uncertain about how far these improvements can be extended, but their direction is unmistakably toward greater energy efficiency, and the results to date are better than expected.

This empirical phenomenon — the "decoupling" of energy growth and economic growth — lends credence to the general point made by the Demand and Conservation Panel of the Committee on Nuclear and Alternative Energy Systems (CONAES) of the National Academy of Science:

> The results indicate that, given time to respond to prices, regulations, and incentives, U.S. energy demand is very elastic. Consequently, a major slowdown in demand growth can be achieved with significant economic growth by substituting technological sophistication for energy consumption.(24)

The report goes on to show how, theoretically, energy consumption in 2010 could be 60 percent less per unit of output (GNP) than in 1973. Although many might dispute this projection as too high (particularly since it involved an assumed four-fold increase in real energy prices), there is a growing technical consensus that significant reductions in energy consumption can be achieved not only without the detrimental results that were commonly predicted a few years ago, but perhaps with enhanced output as well. As we will show in a subsequent section, our own analysis indicates that in 1978 a 32 percent reduction might have been possible with then current technologies and prices relative to 1973 efficiencies.

The very real prospect that we can reduce raw energy consumption without curtailing our lifestyles or our economic growth explains the emerging dominance of the concept of energy productivity: it can co-exist with other underlying motivations for energy policy; it can slow inflation; it is grounded in American traditions of technological development and free enterprise; it can achieve the results that everyone wants without economic and social dislocation; and, therefore, it commands potential support from the broadest constituency.

Fortunately, the concept of energy productivity provides a very useful framework for the development of energy policy. This framework assures that there would be a maximum number of factors competing in the energy marketplace — conventional fuels, "new" energy sources, differently scaled energy delivery systems and improved and new technologies that make energy use more efficient. The overall result of this competition would be performance of required energy services at minimum cost. This is the objective of the least-cost strategy.

Overall Implications Of A Least-Cost Strategy

The nation has been on an unproductive course; it has looked at energy as a diminishing domestic commodity instead of a service which could be provided by many competing sources. We have been developing a least-cost strategy which, we believe, could unleash new competitive forces, multiply consumer choices, force down the real cost of energy services over the long run, cut the demand for energy supplies, and make a substantial contribution to the nation's economic health.

To make a rough test of the validity of our theory, we set up a hypothetical case comparing the actual energy use patterns of 1978 with what would result if energy supply and end use equipment were reconfigured to minimize consumer cost.

The results were more than encouraging. They seem to indicate that if the U.S. had been following a least-cost strategy for the last 10 - 15 years, the results would have been to reduce consumer costs in the range of 17 percent while positively affecting the nation's security and environment. We make no claim for the hypothetical case other than it justifies aggressive pursuit of a least-cost strategy. This we propose to follow.

Our only purpose in publishing these preliminary results is to help change the course of the energy dialogue into what we believe are more productive channels.

Until quite recently the opportunities for increasing energy productivity — achieving the least-cost objective — were difficult to assess. Analysts attempting to determine how consumer demand for energy is affected by energy prices have been hampered by the nature of most energy analysis in the United States to date, which has concentrated on the availability and cost of new energy supplies, not on the nature of the required energy services or the possibilities for economic substitution of more efficient energy conversion systems for raw fuel.

This difficulty is beginning to be overcome; more recent data and analysis have begun to provide some indication of the opportunities for energy substitution and improved productivity. By slightly refining and integrating these data, we can begin to draw a quantitative picture that shows how past energy policies have strayed from the fundamental principle of the U.S. economy — competition — and from the appropriate ultimate goal of energy policy — provision of sufficient energy services at the least cost to the consumer.

1978: Comparing Two Cases

To illustrate the gap between what was and what might have been, we have compared two cases in terms of demand for energy services, energy consumption and energy efficiency: the actual 1978 situation and a hypothetical 1978 situation that would have resulted from application of least-cost principles.*

More explicitly, the hypothetical 1978 case is our estimated response to the question: "How would the nation have provided energy services in 1978 if its capital stock had been reconfigured to be optimal for actual 1978 energy prices?" The result of our analysis can be summarized in the following figures:

Energy Resource or Technology	**Share of Market**	
	Actual 1978 Situation	**Hypothetical Case**
Natural Gas	19%	21%
Oil	36%	26%
Coal (non-electric)	4%	3%
Electricity (purchased)	30%	17%
Technological improvements in energy efficiency**	10%	32%

Significantly, but not surprisingly, the difference in "mix" in the hypothetical case would have produced a different ultimate consumer cost. The actual 1978 per capita cost of energy services was $1146. In the hypothetical case that cost would have been $948. In other words, application of least-cost principles would have resulted in a 17 percent reduction in consumer outlays for 1978 energy services (see Figure 1) and proportional reductions in prior years.

* The analysis described was performed using the Industrial Sector Technology Use Model (ISTUM), the Buildings Energy Conservation Optimization Model (BECOM), and the Transportation Energy Conservation Model (TEC). These models include all energy-using activities in the economy, and assumed the following conditions:

1. The transportation stock was permitted to completely turn over, buildings and industrial plants could be renovated or modified but not replaced structurally, and improved efficiency technologies in the industrial feedstock, construction and utilities sectors were excluded;
2. All decision-makers were assumed to minimize the discounted lifecycle cost of energy service capital investments.

   Capital was charged at an annual cost equal to the capital recovery factor times the installed cost.

   $$\mathrm{CRF} = \frac{i}{1-(1+i)^{-n}}$$

   Where i is .05 and n is the lifetime of the equipment. With minor exceptions, equipment lifetime used were:

   Private vehicles: 10 years
   Commercial vehicles: 15 years
   Structural technologies: 20 years
   Industrial equipment: 25 years

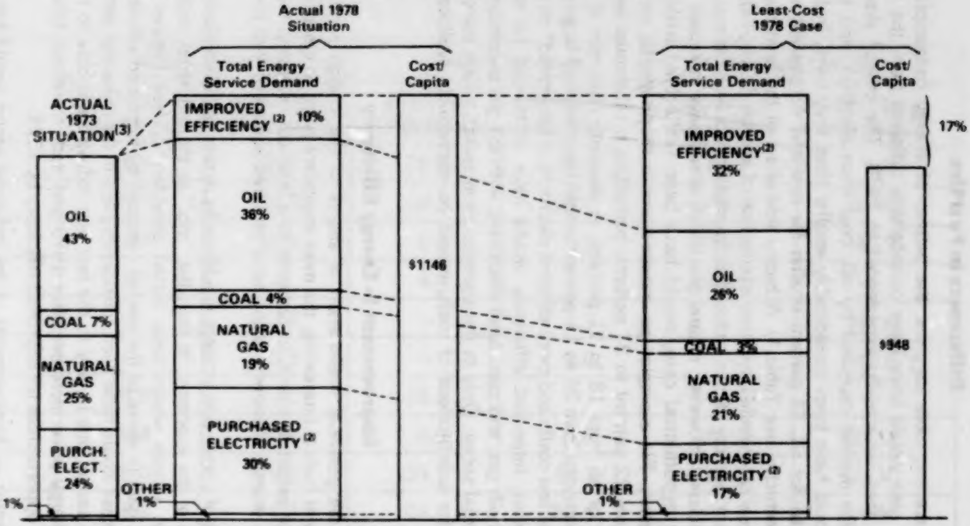
   The total cost per unit of energy service is thus

   TC = CRF x Capital cost/unit of service
   + Fuel cost/unit of service
   + O-M cost/unit of service

   for each competing technology.
3. Capital was available in unlimited quantities at a real 5% cost to all;
4. The level of energy services in 1978 would remain constant, as would 1978 energy source prices. A marginal cost case was also analyzed but not included because it was even less reflective of a dynamic situation.

** Efficiency-improvement technologies were compared to a 1973 base year. In this case we compared energy use to an industrial output index in the industrial sector, total number of residences and commercial square footage in the buildings sector, and GNP in the transportation sector. A calculation of energy/GNP yields very similar results.

FIGURE 1
ENERGY SERVICE MARKET SHARES(1) OF VARIOUS TECHNOLOGIES



(1) THE PRIMARY FUEL EQUIVALENT OF SERVICE DEMAND IN 1978 WAS 79.0 QUADS, PLUS 9.2 QUADS OF IMPROVED EFFICIENCY (CALCULATED AGAINST A BASE OF STOCK AND EQUIPMENT IN PLACE IN 1973), OR A TOTAL OF 88.2 QUADS. ACTUAL SERVICE DEMAND DEPENDS ON THE CONVERSION EFFICIENCY OF THE FUELS AND EQUIPMENT UTILIZED.

(2) IN TERMS OF PRIMARY FUEL

(3) PRIMARY FUEL DEMAND IN 1973 WAS 74.6 QUADS.

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Differences in Fuel Use

As the preceding table suggests, the pattern of energy consumption in the hypothetical case would have been considerably different from the pattern of consumption that we actually experienced in 1978. The overall shares of the energy service market captured by oil, coal (non-electric), and purchased electricity would have been considerably smaller than they were, in fact — 28 percent smaller for oil, 34 percent smaller for coal and 43 percent smaller for purchased electricity (see Table 1). A happy side-effect of the least-cost strategy the hypothetical case would have been a reduction of improted oil by half.

A significant portion of this reduced consumption would have resulted from improved efficiency. However, natural gas, which would have increased its market share in the hypothetical case, would have been reallocated within various economic sectors. For example, gas consumption in the industrial sector would have risen from 22 percent to 37 percent, permitting a substantial reduction in consumption of oil from 18 to 11 percent. A dramatic reduction of industrial purchased electricity from 26 to 11 percent would have resulted largely from the substitution of less costly and more efficient electricity cogenerated* on site. In the buildings sector, improved efficiency would have accounted for substantial reductions in oil, gas, and purchased electricity, with the gas becoming available for the industrial sector. Only in the transportation sector, where there is far less opportunity for substitutions of fuels, would no appreciable reallocation have occurred.

Improvement in Energy Efficiency

Although the potential reallocation of shares of the energy service market among different fuels is interesting, the most important point to emerge from this analysis is the extent to which, in response to a least-cost strategy, technologies that improve energy efficiency might have captured shares of that market from fuels.

The results of a least-cost strategy would not have resulted in an identical "mix" in all sectors of the economy. In fact, the "mix" in the industrial, buildings and transportation sectors would have varied considerably (see Figures 2-4). For example, the gain in share of the market captured by improved efficiency in the hypothetical case would have been considerably less in the industrial sector than in the buildings sector, due largely to the fact that industry was able to react more quickly to energy price increases after 1973 and had, therefore, taken greater advantage of opportunities for improved efficiency by 1978.

Industrial Sector — Improvements in the industrial sector would have resulted primarily from cogeneration, upgrading of boilers and furnaces to higher efficiencies and variable-speed electric motors, although several other technologies such as boiler air/fuel ratio controls and devices that recover waste heat from furnaces called recuperators, would also have accounted for increased shares of the market. The real potential for increased industrial productivity is probably much higher since we were not able to include many technologies we know are currently available.

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* Cogeneration is the simultaneous production of electricity and usable heat.

TABLE 1

1978 FUEL CONSUMPTION[1] (IN QUADRILLION BTU'S)

Fuel	Actual Situation		Least-Cost Case		Difference (%)	
	w/o Elect. Distributed	with Elect. Distributed	w/o Elect. Distributed	with Elect. Distributed	w/o Elect. Distributed	with Elect. Distributed
Gas	16.5	20.1	18.8	20.9	13.9	4.0
Oil	31.6	35.9	22.6	25.1	(28.4)	(30.0)
Coal	3.6	15.4	2.5	9.2	(30.5)	(40.3)
Electricity	7.7	—	4.4	—	(42.8)	—
Nuclear	—	3.3	—	1.9	—	(42.8)
Hydro	—	3.5	—	2.0	—	(42.8)
Electric Generating Losses	18.8	—	10.8	—	(42.8)	—
Other	0.8	0.8	0.6	0.6	(25.0)	(25.0)
Fuel Total	79.0	79.0	59.7	59.7	(24.4)	(24.4)
Improved Efficiency	9.2	9.2	28.5	28.5	209.8	209.8
Total	88.2	88.2	88.2	88.2	—	—

[1] 1978 actual totals used for model calibration and comparison are those reported by the Energy Information Administration, adjusted to include noncommercial biomass and to account for differences between model definitions and EIA reporting conventions. Details are presented in the Technical Appendix.

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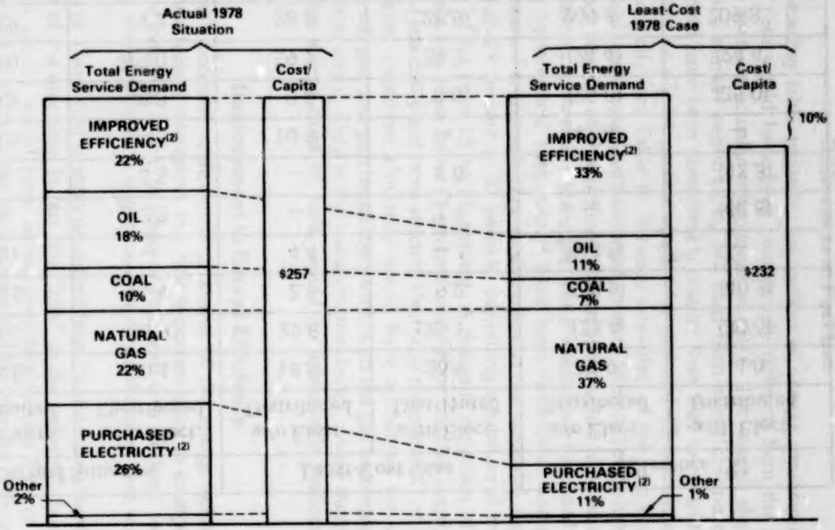
FIGURE 2

INDUSTRY ENERGY SERVICE MARKET SHARES[1] OF VARIOUS TECHNOLOGIES

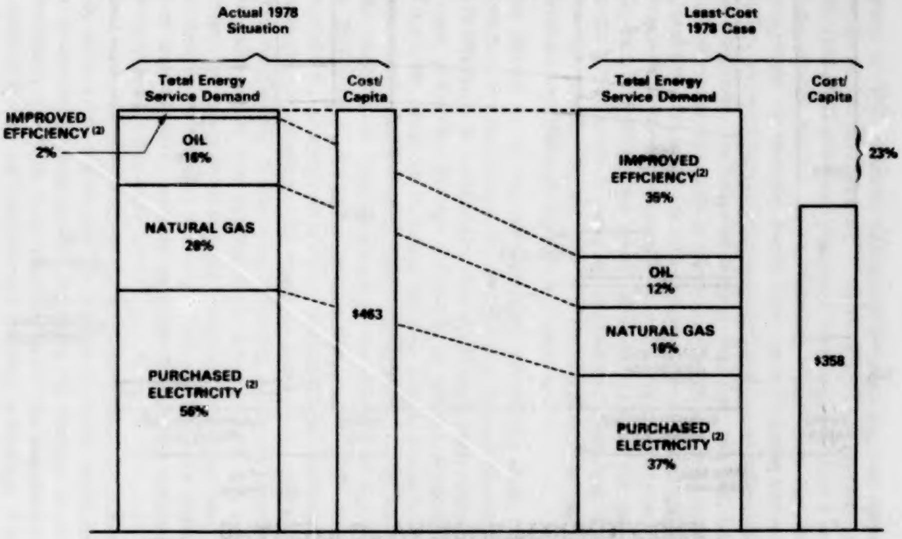


(1) THE PRIMARY FUEL EQUIVALENT OF SERVICE DEMAND WAS 28.2 QUADS, PLUS 7.9 QUADS OF IMPROVED EFFICIENCY AND 0.8 QUADS OF BIOMASS (CALCULATED AGAINST A 1973 BASE), OR A TOTAL OF 36.9 QUADS.

(2) IN TERMS OF PRIMARY FUEL

FIGURE 3

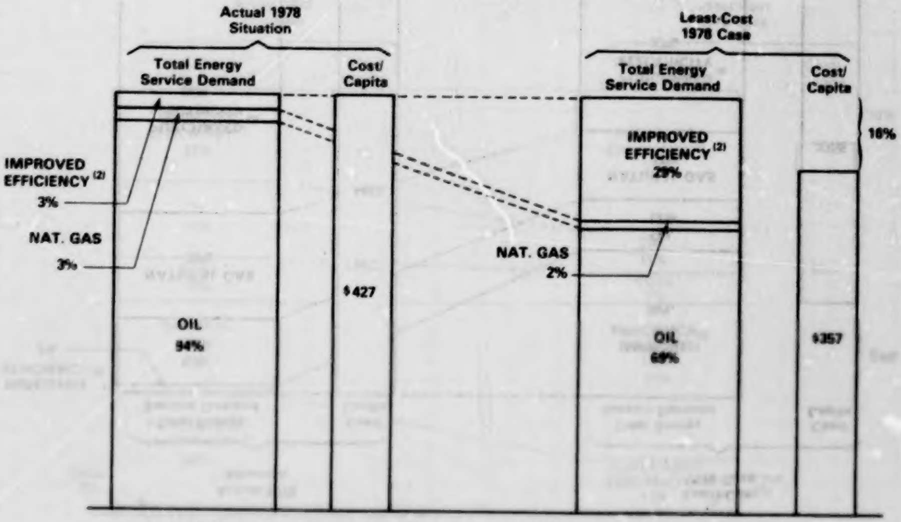
BUILDINGS ENERGY SERVICE MARKET SHARES(1) OF VARIOUS TECHNOLOGIES



(1) THE PRIMARY FUEL EQUIVALENT OF SERVICE DEMAND WAS 29.3 QUADS, PLUS 0.7 QUADS, OF IMPROVED EFFICIENCY (CALCULATED AGAINST A 1973 BASE), OR A TOTAL OF 30.0 QUADS.

(2) IN TERMS OF PRIMARY FUEL.

FIGURE 4
TRANSPORTATION ENERGY SERVICE MARKET SHARES[1] OF VARIOUS TECHNOLOGIES



(1) THE PRIMARY FUEL EQUIVALENT OF SERVICE DEMAND WAS 20.6 QUADS, PLUS 0.6 QUADS OF IMPROVED EFFICIENCY (CALCULATED AGAINST A 1973 BASE), FOR A TOTAL OF 21.2 QUADS.

(2) IN TERMS OF PRIMARY FUEL

Buildings Sector — The dramatic differences between the two cases in the buildings sector are attributable primarily to far more intensive retrofitting of both residential and commercial structures that would have captured over 8 percent of the ***total*** energy service market. The retrofitting would have included both upgrading of equipment, for example, burner tune-ups and heating and ventilating equipment retrofits, and such typical structural modifications as ceiling insulation, storm doors and windows, caulking and weather-stripping. We also found that more substantial improvements, such as injection of additional foam insulation in building walls, reglazing, improved insulation in sub-floor areas and application of diagnostic instruments to identify major energy losses, would have been very cost-effective. Aside from retrofitting, the major difference between the two cases is attributable to the introduction of more energy-efficient appliances that would have occurred in the hypothetical case. Other technologies, such as cogeneration, account for the remaining difference between the two cases.

Transportation Sector — In the transportation sector the most important differences between the two cases are attributable to significantly greater improvements in efficiency in automobiles that would have been achieved in the hypothetical case, primarily through reduction of vehicle weights through substitution of materials, measures to reduce friction, changes in structural design, drivetrain improvements, and increased use of diesel engines. The average fuel economy in the hypothetical case, achieved in the absence of fuel economy standards, was 20.9 mpg — somewhat greater than that of 1978 model year automobiles. In addition, increased use of diesel engines in light- and heavy-weight trucks and substitution of advanced wide-body for narrow-body airplanes would have contributed significantly to improved efficiency in the hypothetical case. Further improvements would have resulted from deregulation of the airline and trucking industries, permitting more efficient schedules and higher load factors. Potential improvements in efficiency that might have resulted from shifts among various modes of transportation, such as airplanes to trains or automobiles to buses, were not considered in this analysis.

The model data base available for this analysis does not reflect the technological progress actually achieved by the automobile industry in recent years, nor is the model capable of accommodating specific technological changes in all of the modes. It was necessary, therefore, to perform portions of the analysis exogenous to the model, employing only well-documented, existing technology. It is likely, therefore, that the productivity improvements achievable in the least-cost case have been underestimated.

Overall Impact of Efficiency Improvements

Taken together, technologies that improve energy efficiency would, in our hypothetical case, have captured 22 percent more of the energy service market than they actually captured in 1978. In other words, these technologies would have enabled us to reduce our total energy consumption by over one-fifth bringing the United States more into line with the levels of energy consumption (per unit of GNP) that have been attained in most other industrialized nations.

Although dozens of technologies would have accounted for the 22 percent market share for increased energy efficiency in our hypothetical case, those which would have had the greatest impact are indicated below in order of impact:

Technology	Share of Energy Service Market (%)
Structural Improvement in Residential Buildings	5.3
Automobile Weight Reduction and Powertrain Improvement	3.2
Improved HVAC Equipment in Buildings	2.0
Gas Turbine Cogeneration (Industry)	1.6
Variable Speed Motors (Industry)	1.1
Appliance Improvements	1.1
Structural Improvements in Commercial Buildings	1.0
Automobile Diesel Engines	0.9
Light Truck Weight Reduction and Powertrain Improvement	0.8
Cogeneration in Buildings	0.7
Improved Aircraft	0.4
Aircraft Deregulation/Load Factor	0.4
Truck Diesel Engines	0.3
Heat Recovery (Industry)	0.3
Truck Deregulation/Load Factor	0.2
All Others	2.7
Total	22.0

Capital Requirements of the Least-Cost Strategy

The cost of implementing these and other cost-effective technologies would have been immense, of course. The efficiency improvements and fuel substitutions that would have occurred in the hypothetical case would have required the investment (in 1978 dollars) of $364 billion: $148 billion in buildings, $43 billion in industry and $173 billion in transportation. (The cost of this capital, as shown in the Technical Appendix, was included in calculating the total cost of various technologies at the rate of five points above the rate of inflation).

The major items composing the $364 billion total investment would have been as follows:

Technology	Total Cost (Billions of Dollars)
Automobile Chassis and Powertrain	93.1
Residential Structural Improvements	88.4
Light Truck Chassis and Powertrain	21.7
Automobile Diesel Engines	21.0
Commercial Structural Improvements	19.5
Cogeneration in Buildings	17.8
New Heating Equipment in Buildings	14.9

Gas Turbine Cogeneration (Industry)	13.6
Variable Speed Electric Motors	10.0
Retrofit Gas Fired Boilers and Burners in Industry	2.3
All Others	61.7
Total	364.0

These investments would have reduced fuel consumption by 19.3 quads. Thus, the average cost of this displaced fuel would have been $2.05 per million BTU or $11.87 per barrel of oil equivalent. ***Total service costs resulting from these investments would have been 10 percent less for industry, 23 percent less for buildings and 16 percent less for transportation — a total of 17 percent less for the average person.***

Such investments in least-cost technologies would have replaced even greater investments in energy production and imports than were actually required in past years. The reduced fuel use that would have resulted from these improvements would have involved, almost entirely, imported oil and utility generated electricity. At a capital cost of $1200 per kw for electricity and actual prices paid for imported oil, these improvements would have precluded the need for investment (in 1978 dollars) of $240 billion in power plants and $161 billion in imported oil. So, although investment to achieve a least-cost objective would have cost a lot of money, it would have cost a lot less than the power plant investment and import bills that were in fact paid in preceding ten years.

Limitations And Opportunities Of The Least-Cost Case

As indicated above, the purpose of this analysis is not to suggest what exactly could have occurred in 1978 under the least-cost strategy. Because rising energy prices have only been a reality for about five years, it would have been unreasonable to have expected that we could have achieved the optimum least-cost "mix" of the hypothetical case in so short a time. In addition, our analysis was based on actual 1978 prices, which might have been considerably different had competitive conditions prevailed during the preceding decade.* The dynamics of a fully competitive market are wonderfully difficult to predict. For instance, if the demand for oil had been as low as in the hypothetical case, the world, or OPEC, oil price would not have been as high as it actually was. Similarly, the price of electricity would have been lower if the demand had been reduced to the level of the hypothetical case.

Furthermore, the analysis should be considered as preliminary and tentative. A number of factors could lead one to question the results. For example, the conclusions assume the operation of a perfect economic market, and such a market will never exist. Non-economic behavioral and institutional factors would have diluted our hypothetical results. (One of the purposes of our continuing research is to learn more about such factors and how they can be influenced.) In addition, the costs of the efficiency technologies might well have been higher than those assumed in the study because those costs might have risen if demand had expanded to the extent calculated in the analysis. On the other hand, we have only begun our research effort to identify technologies which can reduce the cost of energy services, and there are many opportunities which are not yet included in our data base.

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* Also, distortion resulted from mandated priorities for use of natural gas; in the industrial sector (the lowest priority) gas had to be considered a supplementary and unreliable fuel, so its price to industrial users was lower than it would otherwise have been

The chief purpose of this analysis is to demonstrate how we have veered away from the least-cost path — and to demonstrate that other, more productive directions are among our current options. It indicates, ***theoretically***, that consumers paid roughly 17 percent more for energy services in 1978 than they needed to pay. Achieving results comparable to those suggested by our hypothetical case would obviously take some years, but our analysis does indicate the ***direction*** in which we could move to begin realizing some of the benefits of a least-cost strategy.

Interestingly, the results of our analysis also indicate how some of our federal policy initiatives have worked against achievement of least-cost for the consumer:

- Heavy government research and development emphasis has been focused on increasing utility-supplied electricity, despite the fact that in straight-cost competition electricity consumption would have decreased.
- Regulations have forced industrial conversion to coal, as a means of reducing oil imports, despite the fact that at 1978 fuel prices our analysis shows that it was not in the industrial users' economic interest to do so.
- The most cost-effective opportunity to reduce oil consumption is in the building sector, yet government programs have focused on the transportation and industrial sectors.
- Controlled, artifically low prices for natural gas have created excess demand; this has resulted in over-use in the buildings sector because of assured supply to high priority customers and under-use in the industrial sector because the supply was not available. The Natural Gas Policy Act has increased that distortion by passing on the price of higher-cost gas to industry only, thereby encouraging continued over-use in buildings.

The present popularity of a massive government program to produce synthetic fuels well beyond the testing of commercial feasibility is a further example of the propensity of legislators to enact measures that work against achieving the least-cost objective.

Future Evolution Of The Energy "Mix"

If we could apply this same analysis in projecting future cases, the results might be quite different in terms of quantity and the make-up of the "mix"; but the conclusion would probably not be very different in terms of direction and the kinds of changes that would take place in the evolution of our energy situation under a least-cost strategy. As demand for energy sources grows in the future there will be a growing demand for fuels and, consequently, higher fuel prices. As a result, more costly energy sources will become competitive; for example, shale oil and gas from coal will begin to satisfy some of the demand that cannot be supplied by additional production of oil and natural gas. Other sources, too, might come into play: unconventional gas from tight sands and Devonian shale, or, perhaps, from biomass or geopressurized zones. Likewise, solar energy devices would be expected to capture a share of the market. These developments have been the subject of countless analyses of the future "mix" of energy sources.

But efficiency technologies also have a supply curve that is equally or, perhaps, more sensitive to rising prices. With each rise in fuel prices, another technology that improves efficiency becomes competitive for the first time. Thus, within some technical limit as yet unknown, the process of increasing energy productivity can be expected to continue for some time, and we can anticipate future benefits from many technologies not included in our two 1978-based cases. For example, an analysis that projects a future case might incorporate the potential contribution of new structures, which are already demonstrated to be more energy-efficient than retrofitted old structures, new industrial processes and equipment and new transportation technologies, such as electric vehicles. Just as with new fuels, these new technologies would capture a growing share of the market.

A future case might also incorporate some of the interaction of the energy services sector with the rest of the economy. Increased energy productivity would mean fewer dollars spent for energy services and more dollars spent for other things. The result would be greater consumption or investment in other sectors. None of these effects has been considered in the hypothetical 1978 case.

Nevertheless, we can illustrate the potential effectiveness of improved efficiency technologies in the future by extrapolating the results of our hypothetical 1978 case in a further, highly simplified hypothetical case for 1990. In doing so, we have assumed:

- — that GNP would grow 2.5 percent per year in real terms;
- — that efficiency technologies and fuel quantities, including imported oil, in 1990 would be limited to those that were available in 1978,
- — that demand for energy services would remain in the same proportion to GNP as was the case in 1978; and
- — that real prices of fuels and technologies would remain at 1978 levels.

The outcome, shown below, suggests that using the full efficiency potential could provide all but 1 percent of our energy needs — in other words, it suggests that the United States could be using almost the same amount of energy in 1990 that we use today, while satisfying a much larger demand for energy services.

Potential For Improved Fuel Efficiency In 1990 (In Quads)

	Actual 1978 Situation	Hypothetical 1990 Case
Demand for Energy Service	88.2	118.6
Improved Efficiency	9.2	38.3
Oil	31.6	31.6
Natural Gas	16.5	16.5
Coal	3.8	3.8
Purchased Electricity	26.3	26.3
Other	0.8	0.8
Total	88.2	116.7
Deficit	—	1.3

This is not to suggest by any means that this outcome is likely. The reservations that apply to the statistical accuracy of our hypothetical 1978 case, apply with even greater force here. Other fuels and technologies are likely to become available by 1990 and the dynamics of that competition would change the "mix" considerably. And, again, the extrapolation to 1990 is vastly over-simplified. Nevertheless, our assumptions are extremely modest, and these results, like those for the 1978 hypothetical case, do clearly suggest how manageable — or soluable — the energy problem is. They suggest how easy it would be to view the energy problem as manageable, rather than unmanageable because of the ample technical competition that is now available.

The Value Of This Least-Cost Analysis

The analysis presented here is intended to be only directional in nature. It suggests future opportunities; with new research now in process, it can forecast achievable results. Further refinements are in process with regard to service demand data, the technical and economic potential of new technologies (both supply and demand) and the behavioral implications of a changing energy service "mix." Until such refinements are accomplished, however, the data compiled in this analysis can be most useful in identifying some of the new directions in which we can now move to attain the least-cost objective and solve the energy problem.

In addition, this analysis suggests that many of the perceived conflicts between various parties of the energy debate might be quite happily resolved. To those who are primarily concerned with reduction of oil imports, this analysis clearly suggests that a least-cost strategy could help them achieve their goal; in our hypothetical cases, oil imports would have been dramatically reduced. To those concerned about the safety and environmental implications of increased use of fossil fuels and nuclear power, this analysis offers substantial hope; a least-cost strategy would result in less reliance on those two sources of energy. To those who advocate solar and other "soft path" approaches to the energy problem, this analysis indicates that a least-cost strategy would create new opportunities for some of those technologies to become vastly more competitive with conventional energy sources and systems. And, even to those who insist on retaining artificially low energy prices, this analysis shows that their ultimate objective — adequate energy services at the lowest cost to the consumer — would be best achieved in an environment that encourages increased competition in the energy service market — the least-cost strategy.

That, indeed, is why we have given this strategy its name.

Conclusions

Several conclusions from this analysis are evident.

First, past Federal policies have introduced major distortions into the energy/energy service marketplace. Some of these policies, such as those involving mileage standards and price ceilings for gasoline, seek to achieve conflicting goals and tend to negate one another. Other policies have tended to subsidize one component of the marketplace, such as oil, by controlling its price and thereby protecting it from competition from other components. Other policies, such as mandatory industrial coal conversion have compelled consumers to take an unnecessarily high-cost path. A least-cost strategy would require the reassessment of all such past policies.

Secondly, our analysis strongly suggests that the risks and costs of curtailing competition through price controls in the energy/energy service marketplace are significantly greater than the risks and costs of permitting competition to work. Much past regulation of the marketplace has had the perverse effect of placing at a competitive disadvantage fuels and efficiency technologies that might otherwise have helped us to avert the energy problem. ***The most useful policy would be one that encourages the maximum number of competing elements.***

Thirdly, it is apparent that a number of objectives — reduced imports, a cleaner environment, lower consumer costs — which have been treated as conflicting in the past could be largely accomplished ***simultaneously*** through a least-cost strategy. By increasing the available options — the competing technologies — such a strategy would enable us to choose those which are attractive to the largest number of people.

And finally, we have become so accustomed to expecting the government to do something about the energy problem that as private citizens we have failed to react to what is a major opportunity for individual action. This has given government an undue role in energy that has led to further aggravation of the problem.

These conclusions, in turn, suggest some specific areas that should be analyzed in determining future energy policy. Among the questions that should be raised are the following:

(1) Should we allow traditional sellers of energy to become sellers of energy services?

The most natural providers of energy services are the public utilities, the fuel oil dealers and, perhaps, even the gasoline stations. If a gas utility, for instance, were allowed to be a seller of all energy services, not just a seller of natural gas, it could compete with the electric utilities or the fuel oil dealers in providing the total energy service requirements for a home. In addition to gas, the utility could provide cost-effective building modifications, efficiency improvements in the furnace and a more efficient water heater. Structural improvements, such as insulation and storm windows, could be provided through subcontractors. The cost of such improvements could then be billed to the customer monthly over their 20-year lifetime, just as gas is now billed. Electric utilities, fuel oil dealers, and independent manufacturers and contractors could provide competition, assuring the availability of least-cost service to the customer. As new technologies develop, such as gas-fired heat pumps or fuel cells, the utility could offer these additional options to the customer. Other segments of the private sector, such as insulation and furnace contractors, or manufacturers of more efficient furnaces, would compete to provide needed repairs or installations to the utility, or compete directly with the utility in providing services to the customer.

This same approach could be applicable to the industrial and commercial sectors. By focusing on consumer cost of service, the business of providing energy could be transformed from an over-regulated, somewhat monopolistic activity of selling electricity, oil or natural gas into an exciting competitive enterprise of selling energy services. It could also offer utilities a chance to maintain or increase their market share in the face of a possible decline in their traditional product.

We have seen an early example of this approach at the Portland General Electric Company. This far-sighted electric utility provides interest-free loans to residential customers for needed energy improvements in their homes. The company is allowed a return on this investment in their electricity rates to all customers during the time that the loan is outstanding, and the consumer pays the loan only when his residence is sold.

Other private companies, such as Honeywell and General Electric, are likely to offer similar packages. Within the next ten years, the selling of energy, at least in the buildings sector, may be completely replaced by the selling of complete energy services — heat, light, air conditioning and applicance functions.

(2) Should we move to deregulate all activities of the oil, gas and electric industries, except the transmission and distribution of electricity and the oil and gas pipelines?

As the data we have examined indicate, there is no reason to consider the oil, gas and electricity industries as inherently monopolistic. Competition exists in abundance among these fuels, and their continued regulation only subsidizes and protects them from each other and from new competitors. Regulation of oil and gas prices is only supportable if there is no competition, so those who are still opposing relaxation of controls must be shown that competition for oil and gas in delivering energy services to the American people does, in fact, exist.

Similarly, as the data on market shares demonstrate, there is an abundant competition — in the form of industrial cogeneration, small total energy systems and gas and oil heating — for electricity generated by large central utilities. These competing technologies can be offered by private companies, gas utilities or financial institutions. That being the case, there may be no reason to regulate existing power plants as monopolies. They could compete in the energy services market along with these other technologies in supplying the lowest cost services to the consumer through distributors. The only monopolies requiring regulation and protection would be the owners of the pipelines and electrical transmission and distribution networks. However, even the owners of an electrical distribution monopoly would have to compete with gas distribution utilities and fuel oil dealers assuring the least-cost service to the customer.

(3) Should government-sponsored research and development be directed towards different technologies?

Government subsidized research and development of promising low cost energy and energy service technologies have definite contributions to make; but they should be focused on lowering consumer service costs, not reducing imports, and include an expanded share of the budget to develop energy-efficient technologies in proportion to their consumer benefit. Care must be taken not to over-subsidize a given R&D effort, permitting it to take on a self-sustaining (and anti-competitive) life of its own if it becomes an economically dubious prospect for improved energy productivity. This may be the case, presently, with respect to electricity in general and nuclear power in particular, since, according to one recent study, approximately 78 percent of the 1980 Federal R&D energy budget is related to electricity.(25) Again, the same doubts should dampen the current enthusiasm for ***massive*** federal support of development of commercial-size plants (rather than the testing of such plants) to produce synthetic oil and gas, which are not likely to become truly competitive for some years to come.

In addition, our analysis indicates that tax incentives for insulation and solar installations, ***for example***, are very expensive and distorting ways to achieve improved productivity, except as a means of offsetting existing subsidies for energy supplies. Well-focused R&D programs, including commercialization, may be relatively more cost-effective programs for the taxpayer.(26)

* * *

Unfortunately, much of the energy policy debate thus far has emphasized the differences among various approaches to the energy problem and concentrated on the selection of one or the other as an appropriate policy tool. As the example of the automobile mileage efficiency standard suggests, our policy options are interrelated. A mandatory efficiency or fuel-use standard that does not have a basis in consumer economics will be unnecessarily expensive and likely to be circumvented. Similarily, the benefits of providing an incentive under one option could be offset by a disincentive in another area. For example, a tax credit for insulation of a home heated by oil could be offset by maintenance of artificially low oil prices.

This kind of uncoordinated approach has characterized much of our response to the energy problem. As we search for a common thread in our deliberations, the least-cost strategy could help us improve our future record by focusing our attention on the ultimate goal: providing consumers with reliable energy services at a minimum price.

Energy prices that reflect the relative supply of and demand for new and replacement sources are required to stimulate competition and, so, to assure lower consumer costs in the long-run. The phased decontrol of oil and natural gas prices is clearly a step in the right direction. But, as importantly, the common practice of "rolling in" the higher costs of new oil, gas and electric power with the lower costs of existing production in determining prices is an unfair disguise to the consumer and a handicap to new technologies.

As suggested earlier, the overall potential for increasing energy productivity and reducing current consumer costs is substantial. The 10 percent improvement in U.S. energy productivity since 1974 is just the beginning; long-term results will be much greater. Although the least-cost strategy might not result in the 60 percent improvement in energy efficiency by 2010 that the CONAES study indicated is technically possible, or even the 32 percent that our analysis indicates is economically achievable in a much shorter period, the evidence we have provided demonstrates that there is ample competition to hold consumer costs to manageable levels for the required level of energy services. ***The exciting news is that energy productivity provides an expanding opportunity, not a last resort.***

In an overall assessment of this material, one central question remains: improving energy productivity is still an extremely fragmented and disparate activity. Although there may be strong public support for the ***goal*** of minimizing the cost of energy services, there is as yet no unified force for the ***practice*** of achieving that result. Realization of the potential benefits of improved productivity will challenge our ability to bring about changes — not changes in life style or economic expectation, but changes in the way enterprises compete in the energy service market. Traditional energy companies must broaden their view of the market. New contractors, suppliers, manufacturers and service organizations must come into existence. Manufacturers of less costly on-site energy systems must develop the strength to compete with central utility systems. Lenders must adapt their standards to new energy conditions. New technologies must be developed and commercialized.

A wave of optimism — and commitment — is beginning to emerge from many quarters: these changes are possible, desirable and necessary. Perspectives have and will continue to change rapidly. When coupled with ingenuity, new technology and improved management, these changes can be powerful enough to master the energy problem. In fact, seen in this perspective, the problem is transformed into an opportunity — increased employment, new markets, an enhanced environment, a more secure energy future and most important, less onerous levels of energy service costs. We are definitely not stuck with our old attitudes about energy and energy conservation. Our analysis to date shows we can move to higher levels of productivity through a more competitive, consumer-oriented energy policy.

Acknowledgements

This paper is an outgrowth of a development that began in late 1973 and was becoming generally apparent in the Spring and Summer of 1977 — at the time that the Energy Productivity Center was established. At that time fresh doubt was arising about the accepted notion that energy consumption and economic activity were locked into their historic one-to-one relationship. Evidence was accumulating to suggest that they could be "decoupled." The intriguing question was what specific adjustments were taking place in the use of energy in response to the new, post-embargo realities and what further opportunities existed.

By the time our analysis for the Least-Cost Strategy was begun, a year and a half later, various studies — notably those by the Ford Foundation, the National Academy of Science, the Energy Research and Development Administration and the Federal Energy Administration — had, to differing degrees, given various indications of what was taking place or, more often, what could take place in a projected future under different sets of conditions in different areas of the economy. However, no one had attempted to analyze what might be taking place throughout the economy under existing conditions.

As a consequence, we undertook a study, integrating and refining previously developed sets of data, to determine how the U.S. energy situation might have changed, given current technologies and prices, if just one circumstance had been different: the assumption for our analysis was that consumers, in the years prior to our base year of 1978, had foreseen the economic realities of energy in the late 1970's and responded in their own economic self-interest — that is, responded by actions that would have resulted in the least cost to them of the energy services that they required.

Such a study, we felt, might suggest directions in which the United States could move today to assure adequate supplies of energy at affordable prices in the future. On the basis of prior work by others, we suspected what our study might generally reveal. As the results came in, however, we were treated to a number of revelations that lent our effort the excitement of exploring new territory and renewed our enthusiasm in pursuing it to the end.

This excitement and enthusiasm was heightened by the apparent validity of our basic approach: the data indicated that our least cost assumption not only assured minimal costs of energy services but satisfied many others needs as well. As our work progressed, we discerned an increasingly coherent prospect in the chaotic design of the U.S. energy dilemma today. We saw in our results not the well known problems of our energy situation but the array of opportunities that it affords.

If excitement and enthusiasm were generated by our project, the dedication and hard work of many people were no less characteristic. Foremost among those who made it possible was Steve Carhart of the Staff at the Center. A product of the Massachusetts Institute of Technology, an engineering and systems analyst and a veteran of Brookhaven National Laboratory, Steve was instrumental in development of the conceptual framework of this analysis and the coordination and management of the efforts of the many people who contributed to it. His long hours of concentrated work, combined with a genial temperament that elicited maximum support from his colleagues, largely account for this paper's existence.

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References

1. Meadows, Donella H., et. al., *"The Limits to Growth*, (New York: Universe Books, 1972), pages 153-154.

2. National Petroleum Council, ***U.S. Energy Outlook***, December 1972, page 3.

3. Nixon, Richard M., November 7, 1973, "Address on the Energy Emergency," ***Executive Energy Documents***, No. 95-114, (Washington, D.C.: U.S. Senate, 1978), page 86.

4. Federal Energy Administration, ***Project Independence Report***, November 1974, page 19.

5. Federal Energy Administration, 1974. See Ref. 4, page 19.

6. Ford, Gerald R., January 13, 1975, "Address by the President on Live Television and Radio." See Ref. 3, page 172.

7. Federal Energy Administration, ***National Energy Outlook***, (Washington, D.C.: 1976), page 1.

8. The White House, The National Energy Plan, 1977, page IX.

9. The White House, See Ref. 8, page IX.

10. The White House, See Ref. 8, page IX.

11. Carter, Jimmy C., July 15, 1979, ***"Address to the Nation"***, Washington Post, July 16, 1979, page A14.

12. Central Intelligence Agency, ***Handbook of Economic Statistics***, 1978, pages 82 and 88.

13. International Monetary Fund, ***International Financial Statistics***, March 1979, pages 155, 157, 215 and 391.

14. Hayes, Denis, ***Pollution: The Neglected Dimensions***, (Washington, D.C.: Worldwatch Institute, March 1979).

15. Winger, John G. et. al., ***Outlook for Energy in the United States to 1985***, (New York: The Chase Manhattan Bank, 1972) page 52.

16. Meadows, Donella H., et. al., See Ref. 1, page 154.

17. Carter, Jimmy C., July 15, 1979, *"Address to the Nation"*, Washington Post, July 16, 1979, page A14.

18. Sieminski, Adam, "U.S. Energy Consumption 1978:, (Washington, D.C.: Washington Analysis Corporation, March 26, 1979), pages 1 & 2.

19. Energy Users News, April 2, 1979, page 16.

20. American Gas Association, *Energy Analysis*, February 3, 1978, Figure 1, page 4.

21. Private conversation with Dennis Bakke, Director of the Gas Requirements Agency, May 5, 1979.

22. Private conversation with Charles Ince, President AIA Research Corporation, September 12, 1978.

23. Department of Energy, *Transportation Energy Conservation Data Book: Edition 3*, (Oak Ridge, Tennessee: Oak Ridge National Laboratory, February 1979), pages 2-31.

24. American Association for the Advancement of Science, "U.S. Energy Demand: Some Low Energy Futures," *Science*, April 14, 1978, page 143.

25. Whitman, J. Philip, "An Analysis of DOE's Proposed 'FY '80 Budget," American Gas Association, Gas Supply Committee, April, 1979.

26. See Gibbons, John H., "Long Term Research Opportunities," *Energy Conservation and Public Policy*, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1979), pages 210-229.

NEW TECHNOLOGIES
FOR GAS ENERGY
SUPPLY AND EFFICIENT USE

AGA
American Gas Association

Foreword

Recently, there has been a growing awareness among national leaders of the significant potential for gas energy in the U.S., particularly in the area of non-conventional gas supplies. While technology, per se, is not a critical constraint in the further development of some of the more well known non-conventional supplies, such as LNG, SNG, and gas from coal gasification, many other non-conventional supply sources will require significant research, development, and demonstration (RD&D) before their full potential can be realized. These so-called "New Technologies", such as gas from geopressured zones, gas from tight formations, and gas from renewable land and sea biomass are estimated by A.G.A. to potentially contribute up to 5 Tcf or more of gas to the nation's energy supply by the year 2000, and perhaps vastly greater amounts in the years beyond.

On the assumption that many in the general public and government may not be familiar with either the nature or potential of these new technologies, A.G.A. has prepared this booklet which contains a summary overview of the new technologies that could impact on both the *supply* and *utilization* of gas energy in the U.S., including recommendations as to the RD&D needed to bring them to full commercialization. It is my hope that the information contained herein will contribute to an effective federal RD&D program which will be in the best interests of consumers, the economy, and the nation as a whole.

G.H. Lawrence

G. H. Lawrence, *President*

New Technologies for Gas Energy Supply
and Efficient Use

Prepared by the
Policy Evaluation & Analysis Group

AGA American Gas Association

APRIL 1979

Introduction

Over a five-day period in late June 1979, a group of 50 noted scientists, engineers, economists, environmentalists and industry leaders met in Aspen, Colorado, under the sponsorship of the Aspen Institute for Humanistic Studies to discuss "R&D Priorities and the Gas Energy Option." After considerable discussion, the group generally concluded that (1) gas energy has significant advantages over other energy forms from the standpoints of the impact on the environment and the impact on consumer costs, (2) natural and supplemental sources of gas energy are potentially plentiful and should continue to play a significant role in America's energy mix and (3) a vigorous national gas-related R&D program is critical in ensuring that gas will continue to be plentiful in the future. Some of the more specific conclusions reached by the group were:

- Unconventional and supplemental sources of gas, such as coal gasification, tight gas formations and other conventional methane sources, hold significant promise for meeting future national energy needs. Research, development and demonstration should be vigorously pursued to determine their real cost and resolve remaining technical, environmental, institutional and other issues so they may be available for commercial use. Because R&D resources are limited, priorities for gas research, as well as all other energy research, should be focused on those options with the potential for significant energy contribution, as well as those with the lowest costs and minimal environmental impact.
- Inexhaustible sources of methane and/or hydrogen from solar and nuclear energy sources represent important potential long-term U.S. options for maintaining and increasing the production and delivery of gas. Therefore, research, development and demonstration in these energy areas should be continued even though current price projections for their end use are high.
- Gas-related technologies that improve the efficiency of energy use rank among the most cost effective conservation options. Gas furnace improvements, gas turbines that cogenerate electricity and heat, gas-fired heat pumps and fuel cells are examples of technologies that make a combination gas supply/conservation strategy very attractive. Replacement cost pricing of gas will reveal that gas options are often less expensive to the nation than other corresponding additional units of energy.
- Although some of the technologies needed to supply and conserve gas are available today, research should be aggressively pursued to define the production cost and supply potential of unconventional and supplemental gas sources, to improve existing technologies, and to stimulate gas conservation.
- Environmentally acceptable gas supply and conservation technologies that will sustain or expand gas supplies will be brought to commercial use chiefly when price and other regulatory policies permit. The need for fundamental research is not generally the limiting factor in commercializing most new or improved gas technologies. For near-term technologies and those involving proprietary information, government R&D should be used judiciously; however, in some cases, particularly for R&D into inexhaustible sources and construction of the first coal gasification plants, government support will be required.

In light of the conclusions of the Aspen conference, the approximate 4 percent of the proposed FY 1980 Department of Energy R&D budget dedicated to new unconventional gas-related technologies seems inadequate. Accordingly, in an effort to assist in translating the results of this conference into effective R&D action at the federal level, the Policy Evaluation and Analysis Group of the American Gas Association has prepared this booklet to bring together key information on some of the major new technologies both for increasing gas supplies and for making more efficient utilization of gas energy. This booklet is intended to provide the reader with a basic understanding of the potential of these new technologies and the programs needed to make them commercial realities.

Contents and Format

The following new technologies are addressed in this booklet:

- **GAS SUPPLY TECHNOLOGIES**
  - — Devonian Shale
  - — Tight Sands
  - — Geopressured Gas Resources
  - — Coal Seam Methane
  - — In-Situ Coal Gasification
  - — Gas from Marine Biomass
  - — Gas from Land Biomass
  - — Gas from Organic and Municipal Wastes
  - — Peat Gasification
  - — Gas Hydrates
  - — Hydrogen
- **GAS UTILIZATION TECHNOLOGIES**
  - — Gas/Solar Energy Systems
  - — Gas Heat Pumps
  - — Fuel Cells
  - — Ultrahigh Efficiency Furnace

Information for each of these technologies is presented in the following format:

- **Summary**—A brief description of the new technology, including appropriate estimates of production/conservation potential and economics. (Production cost estimates are escalated from current dollars at 5.5 percent per year.)
- **Major Impediments to Commercialization**—A review of the factors which must be resolved before the technology can be commercialized.
- **Major Current Programs**—Ongoing R&D efforts to resolve the obstacles to commercialization.
- **Recommendations for Additional Research, Development and Demonstration**—Efforts required to resolve the obstacles to commercialization above and beyond ongoing programs.

SUMMARY

Devonian Shale

Shale is a rock formation typically formed by the tight compaction of organically rich clay and is the "source rock" in which most conventional natural gas is formed. "Devonian" refers to a type of shale found principally in the Eastern U.S. which was formed in the Devonian geologic era. Although Devonian shale is richer in gas content than the shales in conventional producing areas, gas recovery poses unusual problems. In conventional producing areas, gas is recovered by drilling into relatively permeable adjacent sandstone formations into which gas from the shale has migrated and accumulated over geologic time. In Devonian shale formations, however, most of the gas is entrapped within the shale, and hence has to be recovered by drilling into the shale itself. Since shales by their very nature have relatively low permeability, the rate of flow from a Devonian shale well is therefore significantly less than from a conventional gas well. Devonian shale is estimated to contain upwards of 2000 Tcf of gas in-place, but only about 2-10 percent of it is felt to be economically recoverable at current levels of technology.[1] While there is some commercial production of gas from Devonian shale at present (over 9,000 producing wells have been drilled), such production has been limited to extraction of gas in-place around or below the shale formation. Improved techniques for "fracturing" the shale, i.e., breaking it up so that the gas can flow through it more readily, need to be developed before the Devonian resource can be fully exploited.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Resource Base Uncertainties**
  - Total potential resource base needs to be better defined
  - Quality variations in the shale have to be better identified
- **Technological**
  - Fundamental mechanisms that entrain and control flow of natural gas in shales are not understood
  - Geologic conditions that control well productivity cannot be accurately determined with present measurement technology
- **Economic**
  - Flow rates from current fracturing techniques are too low to be economically attractive
- **Legal**
  - Issues concerning mineral rights have been a continual problem in some Devonian shale areas
  - Site preparation and restoration restrictions may be prohibitive
- **Geographic Barriers**
  - Drilling and pipeline installation costs are substantially higher in some production areas because of rugged terrain and poor roads

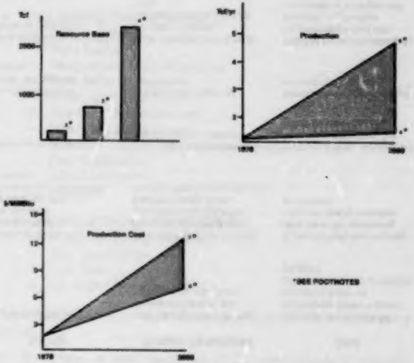
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Eastern Gas Shales Project	DOE (Morgantown Energy Research Center) and participating industries	Develop information for technology base to assist private industry in commercial-scale production program
Acquire, analyze and exchange information on shale resource assessments, drilling, stimulation and completion techniques	DOE (Morgantown Energy Research Center) and Columbia Gas Systems, Mitchell Energy Corp., Thurlow Weed & Associates, Inc.	Systematically accumulate data bank for assessing resource and production economics
Technology evaluation	Columbia Gas System and Gas Research Institute	Improve drilling, logging and fracturing techniques for reservoir development
Joint effort between government agencies and industries	Appalachian Regional Commission	Improve coordination in area of shale development
Drilling directional well and stimulating production	DOE (Morgantown Energy Research Center), Consolidated Gas Supply Corp.	Provide more potential area for stimulation and test feasibility of multiple completions in single well

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Undertake further evaluation of all deep Devonian shale resources, with emphasis on naturally fractured areas
  - — Conduct further testing of current shale stimulation techniques through cost-shared drilling programs with industry
  - — Stress stimulation efficiency and development of dual completion technology in field-based R&D.
  - — Evaluate incentive alternatives, other than deregulation, with respect to high-cost production

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



*SEE FOOTNOTES

FOOTNOTES

[1] John Avila, "Devonian Shale as a Source of Gas," *Natural Gas from Unconventional Resources*, Washington, D.C., National Academy of Sciences, 1976, pp. 73-85

[2] Resource under current technology with no economic constraints in William F. Moran, "Eastern Devonian Shales: Developing Potential for Future Gas Supplies," *A.G.A. Monthly*, Oct. 1976

[3] Resource in-place in Wallace Dewitt, "Current investigation of Devonian Shale by the U.S. Geological Survey," *Natural Gas From Unconventional Geologic Resources*, Washington, D.C., National Academy of Sciences, 1976, pp. 115-116.

[4] Resource in-place in Science Applications, Inc., *Eastern Gas Shale Project*, Prepared for the U.S. Energy Research and Development Administration, June 1977

[5] U.S. Geological Survey, *Working Papers*, MOPPS Oil and Gas Workshop, Reston, Va., May 24-26, 1977

[6] Office of Technology Assessment, "Enhanced Recovery of Oil and Devonian Gas," Washington, D.C., June 1977, Part II

[7] Lewin and Associates, Inc., "Enhanced Recovery of Unconventional Gas," Washington, D.C., Feb. 1978, Volume II

SUMMARY

Tight Sands

Tight sands are gas-containing sandstone formations characterized by low permeability which restricts the flow of gas through the formation and to a well. As a result, massive fracturing of the formation is needed to obtain significant levels of flow. While tight sands are found in many parts of the U.S., the formations with the greatest potential lie in the Rocky Mountains region of Wyoming, Colorado and Utah. Estimates of the in-place resource in the Rocky Mountains are in the 400-600 Tcf range, but the amount of gas which could be economically recovered is estimated at 100-200 Tcf. Small quantities of gas are currently produced in these areas, but only where natural fracturing of the sandstone occurs.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Resource Base Uncertainties**
  - — Extensive assessment of the data base that characterizes the quantity and quality of the gas-bearing formations is needed
- **Technological/Economic**
  - — Improved instrumentation engineering and diagnostic equipment to measure reservoir parameters and fracture performance is needed
  - — Engineering equipment capable of characterizing the producing formation unique to the tight sand's geologic condition is lacking
  - — Effectiveness of different stimulation fracturing techniques is unknown
  - — Well performance is uncertain
- **Legal/Environmental**
  - — Extent to which land management policy will permit energy resource development is unknown

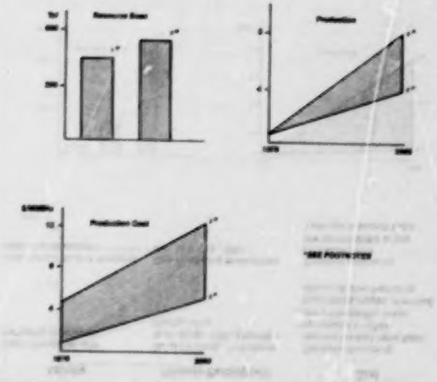
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Experimentation with fracturing techniques	Mobil Oil Corp., Petroleum Tech. Corp., GRI, Mitchell Energy Corp.	Compare fracturing techniques that have been successful in other low-permeability areas Improve hydraulic, chemical and explosive fracturing
Data collection and resource base characterization	Gas Producing Enterprises Inc., U.S.G.S., GRI	Evaluate producing formations and low-permeability areas Estimate resource base

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - Further assess resource-defining geologic variations and extent and quality of gas-bearing formations
  - Improve, through field-based R&D, measurement of reservoir parameters, rock mechanics and fracture performance to develop ability to predict and control stimulated wells
- **Development**
  - Cost-share drilling and testing of wells to further involve producing industry in technology development
- **Demonstration**
  - Demonstrate economic feasibility of production

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



FOOTNOTES

[1] Resource in-place estimated in Federal Energy Regulatory Commission, "Unconventional Natural Gas Resources," Washington, D.C., June 1978, p. [illegible].

[2] Estimate in Lewin and Associates, Inc. "Enhanced Recovery of Unconventional Gas," Washington, D.C., Feb. 1978, Volume [illegible] (Resource in-place in the Green River, Piceance and Uinta Basins).

SUMMARY

Geopressured Gas Resources

Geopressured gas is methane, the chief constituent of natural gas, either free or dissolved in water and trapped in sedimentary rock at higher-than-normal pressure (geopressure). One of the largest geopressured areas underlies a large portion of the Texas and Louisiana Gulf Coast at depths of 5,000 to 15,000 feet depending upon the age and distribution of the sediments. Estimates of the resource in-place range up to 80,000 Tcf, but estimates of recoverable gas are in the 150-2000 Tcf range. While there is no current production of gas from geopressured resources, tests are underway to obtain a better definition of the resource and to develop the advanced technology necessary to produce gas from the resource by 1985.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Resource Base Uncertainties**
  - Size and reservoir characteristics of the geopressured resource have to be better defined
- **Technological/Economic**
  - Feasibility of long-term production is not yet proven
  - Materials capable of withstanding pressures and corrosive environments need to be developed and proven
  - Equipment capable of determining the nature of the resource needs improvement
- **Legal**
  - Stipulations in current state laws concerning land subsidence, resource ownership rights and development priorities, i.e., geothermal versus gas, may need to be revised
- **Environmental**
  - Disposal problems of large quantities of salt water need to be resolved
  - Chemical and physical processes associated with geopressured gas in reservoir conditions need to be better defined
  - Concerns about land subsidence need to be resolved

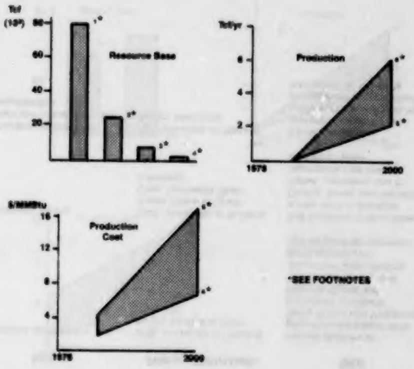
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Resource assessment	DOE, University of Texas at Austin, Louisiana State University	Assess geothermal-geopressured resources in Texas Wilcox and Vicksburg formations, Louisiana Miocene Sands and Tuscaloosa Trends, and Texas Gulf Coast shallow geopressured and hydropressured resources
Production testing	DOE, University of Texas at Austin, General Crude Corp., Louisiana State University	Test feasibility of production in new wells in Brazoria County, Texas, and Cameron Parish, Louisiana, and in recompleted old wells in Cameron Parish
Laboratory research to determine critical reservoir characteristics	IGT, University of Texas at Austin, Intercomp	Develop computer simulation capability for analysis of test well data and development of production and economic forecasts

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Identify optimal additional sites for test wells
  - — Expand resource evaluation of shallow hydropressure and offshore geopressured aquifers
  - — Develop parameters that determine initial gas saturation in aquifers and control ultimate production
- **Development**
  - — Improve bottom-hole sample collection techniques
  - — Improve water disposal techniques
- **Demonstration**
  - — Test feasibility of sustained long-term production
  - — Test impact of two or more wells producing from the same reservoir
  - — Develop plan to implement commercialization program

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



*SEE FOOTNOTES

FOOTNOTES

[1] Resource in-place estimate in Hudson Institute, Research Memorandum No. 31, July 1975.

[2] Resource in-place estimate in U.S.G.S., Circular No. 726, 1975.

[3] Resource in-place estimate by Myron Dorfman in Gas Supply Review, March 1977.

[4] Onshore resource in-place and production estimates in Lewin and Associates, Inc. "Enhanced Recovery of Natural Gas," Vol. II, Feb. 1975.

[5] ERDA, "Market Oriented Program Planning Study," Washington, D.C., Sept. 1977. Final Report.

[6] Extrapolation of "Market Oriented Program Planning Study" estimates based on higher gas/water ratio.

SUMMARY

Coal Seam Methane

Methane occurs naturally in coalbeds, being held by adsorption in the coal or trapped in the natural fractures of the coalbed. Typically, this gas is predrained from coalbeds prior to mining operations since it poses an explosion hazard. At some mine sites the methane is used on site to generate electricity. For other uses, there have been only limited efforts to recover the gas on a commercial scale. Estimates of coal seam methane in virgin or unmined seams range up to 700-800 Tcf.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Resource Base Uncertainties**
  - — Methods for measuring methane in virgin coal seams are inadequate
  - — Characterization of fractures is incomplete
- **Technological**
  - — Production flow rates of conventional drilling are low
  - — No efficient large-scale recovery system has been devised
  - — Promising technology, such as directional drilling through coal seams, is still unproven
- **Economic**
  - — Due to the limited experience in producing and using coal seam methane, development and consumer costs cannot be established with certainty at this time
- **Legal**
  - — Conflicts between mineral rights for natural gas and coal may arise in deeds and leases
  - — Extraction of methane must be balanced with the opportunity to mine coal

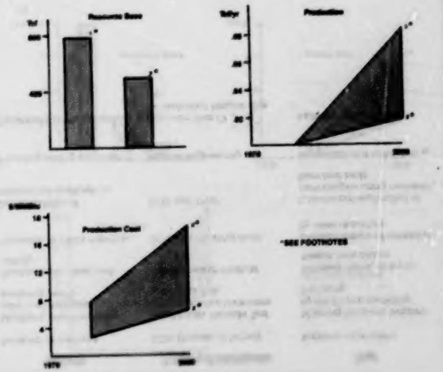
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Removal of methane	DOE (Bureau of Mines)	Improve mine safety
Modifying and monitoring advanced hydraulic fracturing (AHF)	Sandia Lab, Nevada Test Site, Lawrence Livermore Labs, U.S.G.S.	Mapping fractures induced by (AHF) and modeling fracturing
Research into deep well drilling	Gas Research Institute	Increase deliverability in deeper coal seams
Research to utilize methane	DOE and Westinghouse	Develop means of utilization by mine operators
Demonstration of commercial applications	DOE and TRW	Commercial application of technologies using methane from coal beds
Providing drilling expertise	Maurer Engineering and DOE	Installation of a turbo drilling project
Purchasing produced gas	Equitable Gas Co., Consolidated Natural Gas Co.	Increase gas supplies

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Thoroughly assess reservoir and geologic parameters, including natural fracture mapping
  - — Determine how to create a single long hydraulic fracture in a coal seam rather than a network of small fractures
  - — Define the vast resource base of coal and contained methane not scheduled to be mined
- **Development**
  - — Develop a system to provide near-continuous drilling orientation while drilling is in progress
  - — Improve the drill bit guidance system for effective operation in hard sediments like coal
  - — Refine stimulation technologies that increase the permeability of coalbeds without endangering later mining operations
  - — Further develop directional drilling technology through field tests

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



FOOTNOTES

[1] Resource in-place in Department of Energy, FERC, Nonconventional Natural Gas Resources, National Gas Survey, 1978

[2] Resource in-place in ERDA, "Market Oriented Program Planning Study," Washington, D.C., Sept. 1977, Final Report, pp. 9-11.

[3] Lewin and Associates, Inc. "Enhanced Recovery of Unconventional Gas," Washington, D.C., Feb. 1978, Volume II.

SUMMARY

In-Situ Coal Gasification

In-situ coal gasification is the process whereby underground coal is burned in formation, releasing a low-or-medium Btu gas. The coal is gasified by drilling boreholes into the coal seam, igniting the coal and injecting steam, and air or oxygen, into the reaction zone. The hot gas is forced through the seam to an exit borehole where it is carried to the surface and processed to remove impurities. The gas can then be used as an energy source as such, or can be upgraded through catalytic methanation to pipeline quality. In-situ gasification could be particularly useful as a means of obtaining useful energy from unmineable coal resources and, if commercially demonstrated, could triple the economically recoverable reserves of coal in the U.S.[1]

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological**
  - Directional burning has yet to be reliably achieved
  - Long term controlled burning has yet to be demonstrated
  - Applicability to non-Western coals has not yet been established
- **Economics**
  - Production costs are uncertain
  - Transportation costs of low-Btu producer gas from air-blown wells limit market potential to near-site applications; gas from oxygen-blown wells does not suffer from this limitation
- **Legal**
  - Leasing and mineral rights issues need to be resolved
- **Environmental**
  - Underground reactions where waste products could contaminate ground water or where land subsidence could occur are potential problems

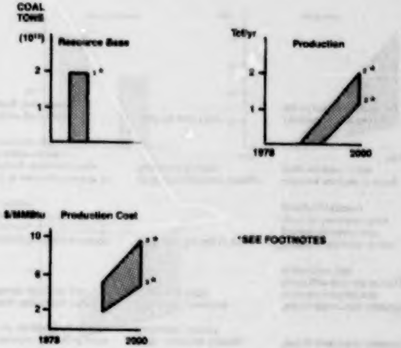
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Combustion linking of wells with air as gasifying agent	DOE, (Laramie Energy Research Center)	Test to determine feasibility
Testing alternative linking methods using oxygen	DOE and Lawrence Livermore Labs	Test to determine feasibility of linked vertical well technique and use of oxygen to produce gas
Developing instrumentation monitoring techniques and process control techniques	DOE and Sandia Labs	Develop accurate above-ground monitors and controls for subsurface gasifying process
R&D to develop process for gasifying relatively deep, thin-seam eastern bituminous coal	DOE (Morgantown Energy Research Center)	Achieve method of using deep eastern coals
Tests to gasify steeply dipping coal seams	Gulf Oil and TRW	Determine feasibility of slant-hole technique

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Undertake assessment of the environmental impacts of underground gasification
  - — Test in-situ gasification of steeply dipping coal beds
  - — Test the simultaneous gasification of parallel coal seams
- **Demonstration**
  - — Demonstrate the varying conversion processes on a large scale to bring about commercial production

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



*SEE FOOTNOTES

FOOTNOTES

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[1] Paul R. Wieber, "Synthetic Natural Gas from the Underground Gasification of Coal," Gas Supply Review, Oct. 1977.

[2] Communication with Lawrence Livermore Laboratory, 1978.

[3] GRI, "Review of Gas Supply Program," 1978.

SUMMARY

Gas from Marine Biomass

Renewable sources of marine biomass can be converted to gaseous fuels using either thermal decomposition or anaerobic digestion—i.e. the biological breakdown of organic matter into methane and other materials by bacterial action in the absence of oxygen. Feedstock for this energy source is aquatic matter grown and harvested from energy farms specifically for gas production. Potential farm areas include all coastal and open ocean waters of the United States. An area 165 miles square to 335 miles square can potentially supply enough gas to meet current U.S. gas demands. An integrated program which includes open ocean farming, harvesting and conversion to pipeline quality gas as well as utilization and recovery of co-products and by-products is presently underway. A biological test farm with adult kelp plants is now in operation off the coast of Southern California.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological/Economic**
  - A controlled cultivation system that will produce commercially viable yields must be established
  - An economic and low-energy-consuming nutrient supply system to give acceptable growth rates year round must be developed
  - Harvesting, transportation and handling systems must be further developed beyond present capacity
  - Biomass conversion technology must be optimized to obtain maximum gas yield and reduce capital investment
- **Environmental/Legal**
  - Impact of large-scale aquatic biomass farms on the environment needs assessment
  - Major uncertainties exist in the political and legal aspects of large-scale implementation

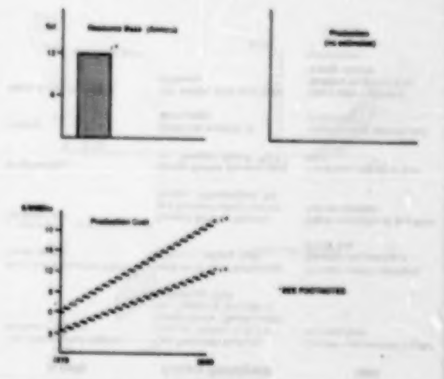
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
"The Energy from Marine Biomass Program"	Gas Research Institute, General Electric, U.S.D.A.; Global Marine Development Inc., California Institute of Technology, DOE	Develop commercial marine biomass farm
Biological experimentation Development	Institute of Gas Technology U.S.D.A., Albany, Calif.	Convert kelp to methane Develop pretreatment processes
Development	General Electric Reentry and Environmental System Division, Philadelphia, Pa.	Study feasibility of gas from marine biomass
Engineering	Global Marine Development Inc., Newport Beach, Calif.	Construct biological test farm
Testing	California Institute of Technology	Observe kelp growth and proliferation
Water Hyacinth Project	IGT, NASA, EPA and State of Florida	Use waste treatment facilities for growing an energy source

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Continue growth and cultivation experiments on feedstocks in different water locations to determine maximum yield and large-scale farming potential
  - — Maintain a strong, well-balanced program in biomass conversion technology development with emphasis on scale-up, maximum gas production, and by-product recovery
- **Development**
  - — Establish a development program to improve farm scale-up, farm deployment and farm structure reliability
  - — Establish a development program to harness environmental energy to benefit the integrated system whenever feasible
  - — Study availability and biological compatibility of materials of construction, and develop new materials
  - — Conduct assessment of institutional barriers to commercial development

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



FOOTNOTES

*Maximum annual production based on Gas Research Institute, "Review of Gas Supply Program," 1979.

SUMMARY

Gas from Land Biomass

Gas can be produced from land biomass utilizing thermal decomposition or anaerobic digestion—i.e., the biological breakdown of organic matter into methane and other materials in the absence of oxygen. Feedstock for this source of gas is land plant matter specifically grown and harvested for gas production. Plant material may include grasses, woody plants and crop residue. Because of competing uses of land and water, the gas potential from land biomass is not as large as the gas potential from water-based biomass. Land biomass has an ultimate potential of 7-11 quads of energy/year if all available marginal land suitable for growing crops is utilized.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Resource Base Uncertainties**
  - — Plants suitable for energy farming and for conversion to gas are still to be defined
  - — Crops used for biomass feedstocks must be cultivated since natural plantings yield less than half the organic materials of managed plantings
- **Technological/Economic**
  - — Competition exists for land and water use with timber and agricultural crops
  - — Cultivation, harvesting and conversion systems have not been optimized for specific crops

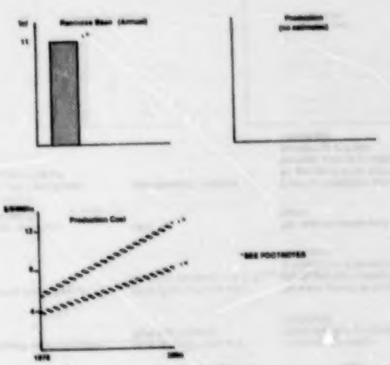
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Biological experimentation	DOE (Energy Fuels and Biomass Division)	Improve conversion processes and production of feedstocks
Planting and cultivation	DOE (Energy Fuels and Biomass Division), U.S.D.A.	Increase growth and yield of plants and optimization of cultivation and harvesting techniques
Design and plant engineering	EPA	Develop demonstration plants
Gas from Land-Based Biomass Program	Gas Research Institute	Develop integrated system for gas production from land biomass including cultivation, harvesting and gas conversion

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Determine biological gasification characteristics of a variety of land biomass species to select species for gas generation
  - — Perfect organisms used in anaerobic digestion for maximum gas production from land biomass species
- **Development**
  - — Refine pretreatment techniques for all selected feedstocks
  - — Institute optimum operating conditions for gasification
  - — Develop cultivation and harvesting techniques for optimum yields of land biomass
- **Demonstration**
  - — Perform required scale-up work to prototype commercial systems

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



FOOTNOTES

[1] Gas Research Institute "Review of Gas Supply Program," 1978.

SUMMARY

Gas from Organic and Municipal Wastes

Gas can be produced from organic and municipal wastes utilizing thermal decomposition or anaerobic digestion—i.e., the biological breakdown of organic matter into methane and other materials in the absence of oxygen. At present, large scale commercial sewage treatment plants using anaerobic digestion techniques are in operation producing by-product gas (low and medium Btu) for local consumption. It is estimated that up to 4 Tcf/yr could be produced from this source by the year 2000. A consideration in this technology is the social benefit of converting municipal wastes into useful energy.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological**
  - — Improved gas conversion efficiencies and process operability are needed
- **Economic**
  - — Competition exists with fertilizer uses of animal wastes
  - — Costs/benefits must be compared with conventional disposal
  - — Cost of product gas has to be competitive with alternate sources of supply

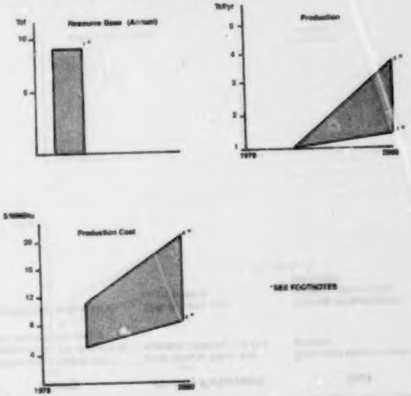
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Collection of wastes and assessment of both bacterial and thermal processing	DOE (Energy Fuels and Biomass Division) U.S.D.A.	Determine best conversion process
Cost/Benefit evaluation	EPA, Industry and Municipalities	Develop demonstration projects, commercial production

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Develop advanced conversion technologies
- **Demonstration**
  - — Provide additional federal financial assistance to municipalities and local utilities to demonstrate feasibility on a national scale as well as federal assistance for overcoming land use or other institutional barriers to commercialization
  - — Determine markets for process by-products

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



*SEE FOOTNOTES

FOOTNOTES

[1] Total waste generated in Tcf equivalent based on Bureau of Mines, Circular 8549, 1972.

[2] U.S. Forest Service, "A National Framework for Energy From Biomass," Preliminary Draft, April 28, 1976.

[3] Gas Research Institute, "Review of Gas Supply Program," 1976.

[4] Dynatech R/D Company, "Fuel Production from Solid Waste," Cambridge, Mass., July 31, 1974.

SUMMARY

Peat Gasification

Peat is geologically young coal. It is formed when plant matter partially decomposes under water or in a water-saturated environment. Peat is currently used in the U.S. for soil improvement purposes rather than fuel. However, air-dried peat can be burned directly in a manner similar to coal and is used as an energy source in the Soviet Union and Europe. Peat is chemically very reactive and can be converted into clean pipeline-quality gas. Gasification of peat is, in some respects, easier than gasification of coal since less severe operating conditions are needed in the reactor. In the U.S., the energy equivalent of peat resources exceeds that of any other fossil fuel but coal. Alaska alone has 740 quads and the contiguous 48 states have an additional 680 quads concentrated mostly in Minnesota, Wisconsin, Michigan and 11 other states.[1]

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological**
  - — Harvesting and dewatering peat on a commercial scale must be demonstrated
  - — New gasification processes unique to peat need to be developed through pilot plant and demonstration plant stages
- **Economic**
  - — Economics of peat gasification are uncertain
  - — Transportation of peat is uneconomical over large distances
  - — Mined peat is wet and must be air-dried (maximum 35% moisture) before grinding for silo storage, pneumatic transfer or as feed to a fluidized bed reactor
- **Environmental**
  - — Large areas must be drained and mined for significant gas production
  - — Land reclamation techniques need demonstration and economic assessment

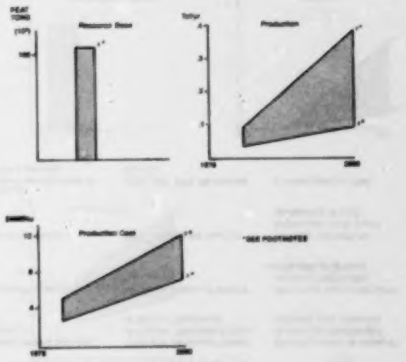
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Literature review and data collection	Technical Research Center of Finland, Minnesota Dept. of Natural Resources	Compile previous research in peat gasification and estimate peat reserves
Cost/benefit analysis	Minnesota Dept. of Natural Resources	Determine socio-economic impact of large peat utilization programs
Resource extraction	DOE, Minnesota Gas Co.	Develop methods for large-scale mining and dewatering of peat
Pilot plant development of PEATGAS process	DOE, IGT, GRI, Minnesota Gas Co.	Convert peat to SNG

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - Conduct basic research on peat characteristics as a function of geographical distribution and local site conditions
- **Development**
  - Improve mining techniques
  - Improve large-scale drying techniques
  - Assess land reclamation impact
- **Demonstration**
  - Test at least one peat gasification process in a coal gasification pilot plant
  - Prepare a detailed economic evaluation and commercial program implementation plan

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



FOOTNOTES

[1] D. V. Punwani, A. H. Rader, "Peat Gasification for SNG Production," Paper presented at the Ninth Synthetic Pipeline Gas Symposium, Chicago, Oct. 31, 1977

[2] Resource in-place in U.S. Department of Agriculture, Soil Conservation Services, "Conservation Needs Inventory," by Dr. R. S. Farnham, 1967

[3] Communication with Punwani, IGT

SUMMARY

Gas Hydrates

Gas hydrates are solid, ice-like compounds in which the gas molecules are entrapped and bound to water molecules. Recently, it has been recognized that natural gas hydrates may occur naturally in some permafrost zones and some ocean sediments. While most of the research on gas hydrates in sediments has been conducted in the Soviet Union, drilling in the North American Arctic and the offshore Atlantic have reportedly confirmed their existence. Estimates of the total world in-place resource of gas in the gas hydrate form range up to 30 million Tcf.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Resource Base Uncertainties**
  - No estimates of U.S. resource base are available
- **Technological**
  - No proven production technology exists in the Western world
  - Cost effective means of production have not been defined
- **Environmental/Economic**
  - Largely unknown
- **Legal**
  - Mineral rights may be a problem
- **Economic**
  - Means to transport methane from hydrate locations to U.S. consumers do not yet exist

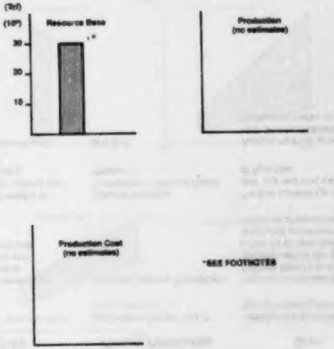
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Research on core samples	Exploration companies in Arctic regions	Assess characteristics of hydrate-bearing formations
Laboratory research on hydrate resource characteristics and production methods	National Science Foundation	Improve understanding of hydrate formation and decomposition (for gas production) and establish improved understanding of resource characteristics
Evaluation of results of oceanographic drilling and acoustical testing	National Science Foundation, Office of Naval Research	Further knowledge of geology and test existence of hydrates
Resource research and production	U.S.S.R.	Assess hydrate potential and develop feasible production methods

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Establish a program to study the relationship between wire-line log data, acoustic reflections and hydrate formation conditions to better establish the resource potential
  - — Encourage programs aimed at identifying specific locations where established data reveal the presence or possibility of gas hydrates in North America
  - — Take core samples from possible hydrate bearing sediments
  - — Initiate a laboratory program to evaluate various driving forces for hydrate decomposition; these techniques would be candidate production methods
  - — Develop preliminary estimates of the economics of producing natural gas from gas hydrates
  - — Institute a program to evaluate, develop and test the most promising candidate production methods
  - — Based on candidate production methods, economics and resource location, study problems of gas delivery, environmental and institutional effects, and compare gas hydrates with other unconventional gas sources (geopressured zones, tight sands, Devonian shales)

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



FOOTNOTES

[1] GRI, "Review of Gas Supply Program," 1978 (World estimate).

SUMMARY

Hydrogen

Hydrogen is a potential supplement and/or replacement for natural gas. As a supplement, tests have shown that up to 25 percent (by volume) of hydrogen can be blended with natural gas with little adverse affect on existing natural gas transmission, distribution and utilization systems. Greater concentrations of hydrogen will require significant system modifications. While hydrogen is currently produced commercially for petrochemical uses, the cost of hydrogen from state-of-the-art technologies precludes its use as a fuel. New technologies such as thermochemical decomposition of water are now under development and show promise of bulk hydrogen production at lower costs.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological**
  - — Commercial storage capability for gas utility industry is not proven
  - — Excessive leakage and pipeline embrittlement may occur during transmission
  - — Blending with natural gas is limited to 25% maximum without extensive system modifications
  - — Efficient, low-cost bulk hydrogen production technology must be developed
  - — Heat sources, such as solar collectors, for use in hydrogen production need to be developed
- **Economic**
  - — Economics of current technologies are unattractive
- **Legal**
  - — Codes and regulations governing construction of pipelines, appliances and metering devices may need to be changed
- **Availability of Low-Cost Energy**
  - — Restrictions on development of nuclear facilities, the most likely sources of heat for thermal decomposition, may hinder hydrogen development

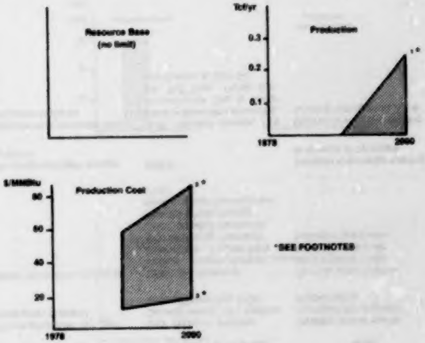
MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Thermochemical hydrogen production research	Gas Research Institute, General Atomic Co., Institute of Gas Technology, DOE	Develop processes for hydrogen for long-term supply option
Water electrolysis concepts	DOE, Gas Research Institute, Niagara Mohawk Power Corp., Empire State Electric Energy Research Corp., General Electric Co., New York State Energy Research and Development Corp.	Develop solid polymer electrolyte for water electrolysis for bulk hydrogen production
Studying hydrogen storage systems	NASA	Increase knowledge relating to storage of hydrogen
Researching production and utilization systems	DOE, General Electric, Los Alamos Scientific Laboratory, Pennsylvania Gas & Water Co., EIC Corp., Public Service Electric & Gas Co.	Improve knowledge relating to using hydrogen as a fuel

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Continue government-industry cost-shared programs in hydrogen production by closed loop thermochemical processes, development of advanced water electrolysis concepts and a supporting program on materials catalysts development and engineering/economic assessments

ESTIMATES OF RESOURCE BASE, PRODUCTION AND PRODUCTION COST



*SEE FOOTNOTES

FOOTNOTES

[1] U.S. Department of Energy, Hydrogen Energy Storage Program (DOE/CR0040), April 1978.

[2] Glen G. Johnson, et al. "Hydrogen Energy from Small Falling Water Facilities at Existing Dams," Paper No. [illegible], presented at ASME Energy Technology Conference and Exhibition, Houston, Tex., Nov 5-9, 1978.

[3] U.S. Department of Energy, Proceedings of the DOE Chemical/Hydrogen Energy Systems Contractor Review, Hunt Valley, Md., Nov. 16-17, 1977.

SUMMARY

Gas/Solar Energy Systems

Solar energy can be utilized as a complement to natural gas in many uses. The near-term applications of gas/solar systems are space conditioning, hot water heating, and industrial and agricultural uses where temperatures less than about 500°F are suitable.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological/Economic**
  - — Capital costs for solar equipment are a formidable barrier to market penetration, especially in the residential sector
  - — Gas/solar systems typically have long-term paybacks
- **Legal/Regulatory**
  - — Many issues concerning solar systems remain unresolved, including the right of a system to receive unshaded sunlight ("sunrights")

MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Research and development of gas/solar systems	GRI, DOE, individual utilities	Achieve economic integrated gas/solar heating and cooling systems, and develop gas/solar hot water heater
Evaluation of gas/solar applications in current gas-only markets	GRI, A.G.A., individual utilities	Increase applications of gas/solar systems for residential and commercial space-conditioning and in industrial processes
Installation of experimental gas/solar systems in homes Evaluation of various financial mechanisms to facilitate residential installations	Southern California Gas Co. (SAGE Program) Various gas utility companies	Commercialize solar water heating with gas backup Increase utilization of gas/solar systems in residential markets

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Development**
  - — Improve gas/solar system compatibility
- **Demonstration**
  - — Demonstrate solar augmentation of industrial processes

SUMMARY

Gas Heat Pumps

The gas heat pump works on the principle that there is heat in the air no matter how "cold" it may seem to be. Even on a cold day a heat pump can extract some heat from the outdoor air and pump this heat into a home to maintain a comfortable temperature. Because of the inherent characteristics of the heat pump cycle, the energy required to heat and cool a house with this technology can be about half of that required with conventional space conditioning systems.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological/Economic**
  - — Gas fired heat pumps with efficiency comparable to gas forced-air furnaces have yet to be demonstrated
  - — Initial capital costs are no' yet competitive with other space conditioning systems
  - — Commercial operational reliability and life-cycle performance have not yet been verified

MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
R&D on Stirling-Rankine heat pump	GRI, General Electric, DOE	Complete development of cost-competitive, reliable equipment for residential and commercial use
R&D on absorption heat pump system	GRI, Allied Chemical Corp.	Complete development of cost-competitive, reliable equipment for residential use
R&D on Brayton-Rankine heat pump system	GRI, Garrett Corp.	Complete development of cost-competitive, reliable equipment for commercial use
R&D on Rankine-Rankine heat pump system	GRI, Mechanical Technology Inc.	Demonstrate advanced heat pump concept which does not require a defrost cycle and provides its own electrical power

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Conduct a thorough study of candidate thermodynamic cycles that can be converted into gas heat pumps
- **Development**
  - — Devise a total space conditioning system that heats, cools, humidifies and collects airborne materials and vapors
  - — Construct heat-activated, free-piston Stirling engines driving a free-piston, inertia-type Rankine cycle compressor, 10 tons and above, for commercial-size heat pumps
  - — Refine advanced heat pump systems with direct-fired prime movers coupled to compressors using conventional refrigerants capable of using the maximum amount of heat in the fuel source
  - — Conduct an analysis of the highly reliable single pressure cycle of the gas refrigerator to determine if it is feasible for gas heat pump applications
- **Demonstration**
  - — Fabricate pre-production units and deploy in various applications to determine market feasibility once prototype unit work and testing are completed

SUMMARY

Fuel Cells

Fuel cells are devices for converting the energy content of fuels, such as natural gas, coal gas, light distillates and hydrogen, directly into electricity via an electro-chemical process. The process is continuous as long as fuel and air are supplied and a load is connected. At present technology levels, a single fuel cell generates roughly 150 to 200 watts of electricity for each square foot of electrode area at a potential on the order of 1 volt. Power levels from kilowatts to megawatts can be generated by connecting individual fuel cells in parallel. The waste heat from a fuel cell system (a steam and CO_2 mixture) can be used for electric generation.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological/Economic**
  - — Current technology is uneconomic in most applications
- **Legal**
  - — There is no operational history from which to develop code requirements

MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
R&D to develop fuel cell power plants in the 10-250 kW range	GRI, DOE, gas and electric utilities in U.S., Canada and Japan	Establish operational feasibility and measure reliability of 40 kW power plant as a key element of on-site energy systems Verify fuel conservation and environmental characteristics of on-site fuel cell energy systems Evaluate institutional, regulatory (PUC involvement), code and legal issues under various simulated ownership arrangements Verify practicality of different on-site fuel cell energy system configurations in variety of applications and conditions Verify over-all viability of attractive early-entry market candidates Assess performance and economics, including capital costs, installation costs, and operating and maintenance costs Inform public of concept in order to prepare for broader acceptance by society Identify power plant improvements requiring design iteration as result of in-service operation

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Conduct a basic research program to uncover concepts for a "direct gas" fuel cell operation (i.e., without the requirements for a reformer)
  - — Conduct basic electrochemical studies on alkaline cells, solid polymer electrolytes and solid oxide cells as third generation gas fuel cell systems
- **Development**
  - — Fully develop the high-temperature, molten carbonate fuel cell for residential and commercial applications in various sizes for tandem or solo operation
  - — Complete final technology improvements for lower cost and longer lifetime first generation technology and for phosphoric acid fuel cell equipment

SUMMARY

Ultrahigh Efficiency Furnace

An experimental pulse combustion furnace has been developed at the A.G.A. Laboratories which operates with a steady-state efficiency in excess of 90 percent. This represents a 15 to 35 percent increase in steady-state efficiency when compared with conventional gas furnaces. The self-powered burner draws combustion air from and vents combustion products to the outdoors through relatively small ducts. Hence, conventional losses of conditioned air are virtually eliminated, and the seasonal efficiency is essentially the same as that at steady-state.

MAJOR IMPEDIMENTS TO COMMERCIALIZATION

- **Technological**
  - Operating noise has been reduced to a relatively low level, but efforts to further improve it are continuing
  - Actual field installation and operation of prototype units must be conducted to determine operability and maintainability
- **Legal/Regulatory**
  - Acceptability to code authorities of plastic tubing for combustion air and exhaust needs to be determined

MAJOR CURRENT PROGRAMS

Activity	Primary Participants	Goal
Construction of prototype high-efficiency furnace for early field testing in cooperation with a furnace manufacturer, a controls manufacturer and gas utilities	GRI, A.G.A. Laboratories, Lennox Industries, Inc.	Develop a cost-effective, reliable gas furnace system for residential use

RECOMMENDATIONS FOR ADDITIONAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

- **Research**
  - — Investigate the pulse combustion burning process through high speed photography in regards to flame stability, self-reignition and effects of gas composition on burner operation
  - — Develop information regarding the heat transfer mechanism whereby simpler, more economical systems may be built
  - — Study application of the pulse combustion concept to determine its applicability in a heat pump mode, as a fast recovery water heater, etc.

EXECUTIVE SUMMARY

WORKSHOP
ON
R&D PRIORITIES AND THE GAS ENERGY OPTION

June, 1978
Aspen, Colorado

Sponsored By
The Aspen Institute for Humanistic Studies

In Cooperation With
The American Gas Association
and
The Gas Research Institute

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ON
R&D PRIORITIES AND THE GAS ENERGY OPTION

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Sponsored By

The Aspen Institute for Humanistic Studies
Dr. John Sawhill, Energy Committee Chairman
President, New York University

In Cooperation With

The American Gas Association
George H. Lawrence, President

and

The Gas Research Institute
Dr. Henry R. Linden, President

TABLE OF CONTENTS

1. WORKSHOP CONCLUSIONS 1

2. SESSIONS

I. U.S. and World Energy Future and the Role of Gaseous Fuels. 5

II. Future for Conventional U.S. Natural Gas Supply 9

III. Environmental Implications of Increased Reliance on Gas. 13

IV. Gasification of Non-Renewable Resources--Coal, Oil Shale, Peat, and Other Fossil Fuels 17

V. Advanced Recovery Methods and Unconventional Sources of Natural Gas. . . . 19

VI. Gas from Advanced Technologies and Renewable Resources 21

VII. Conservation and Improved Gas Utilization. . 25

VIII. Commercialization and Energy R&D Policy. . . 27

3. WORKSHOP PARTICIPANTS AND STAFF. 31

WORKSHOP CONCLUSIONS

Introduction

Over a five-day period in late June 1978, a group of 50 noted scientists, engineers, economists, environmentalists, and industry leaders met in Aspen, Colorado, to discuss "R&D Priorities and the Gas Energy Option." They concluded that the natural and supplemental sources of gas energy are potentially plentiful and should continue to play a significant part in America's energy mix. The group further concluded that a vigorous national gas-related R&D program is an equally critical factor in assuring that gas will continue to be plentiful in the future. These conclusions were reached considering a variety of factors including environmental requirements and consumer costs.

The Conference, sponsored by the Aspen Institute in cooperation with the American Gas Association and the Gas Research Institute, was organized under the auspices of the Institute's Committee on Energy, chaired by Dr. John Sawhill, President of New York University.

The Workshop was organized into eight sessions: "U.S. and World Energy Future and the Role of Gaseous Fuels," chaired by Charles Hitch, President of Resources for the Future; "Future for Conventional U.S. Natural Gas Supply," chaired by Dr. David Sternlight, Chief Economist of the Atlantic Richfield Company; "Environmental Implications of Increased Reliance on Gas," chaired by Laurence Moss, Environmental Consultant; "Gasification of Non-Renewable Resources--Coal, Oil Shale, Peat, and Other Fossil Fuels," chaired by Dr. Lawrence Swabb, Jr., Vice President of Exxon Research and Engineering Company; "Advanced Recovery Methods and Unconventional Sources of Natural Gas," chaired by Dr. James Sharp, President of Gulf Universities Research Consortium; "Gas from Advanced Technologies and Renewable Resources," chaired by Dr. John Foster, Vice President and General Manager of Energy Systems, TRW, Inc.; "Conservation and Improved Gas Utilization," chaired by Roger Sant, Director, Energy Conservation Policy Center of Carnegie-Mellon Institute of Research; and "Commercialization and Energy R&D Policy," chaired by Robert Fri.

Major Conclusions of Conference

1. Even if world supplies of oil and gas are adequate to avoid severe shortages and sharply higher imported energy prices in the 1980s or 1990s, it is in the U.S. national interest to minimize energy imports.

2. U.S. resources of conventional natural gas are large, constituting 30 to 60 times current annual production levels. With relaxation of price controls for new natural gas, current production levels of gas in the U.S. can be sustained, and perhaps even increased, at prices comparable to projected prices for fuels refined from imported oil. Pricing of new natural gas at competitive fuel prices will also very likely result in increased conservation by U.S. consumers.

3. Conventional sources of gas energy, because they are principally composed of clean-burning methane, generally represent the most environmentally acceptable of all major domestic energy sources that could be available for use in the U.S. in significant quantities in this century. Unconventional gas, although less is known about impacts resulting from its production, may also be relatively attractive with respect to the environment, though problems are often greater than for conventional gas.

4. Unconventional and supplemental sources of gas, such as coal gasification, tight gas formations, and other unconventional methane sources, hold significant promise for meeting future national energy needs. Research, development, and demonstration should be vigorously pursued to determine their real cost and resolve remaining technical, environmental, institutional, and other issues, so that they may be available for commercial use. Because R&D resources are limited, priorities for gas research, as well as all other energy research, should be focused on those options with the potential for significant energy contribution, as well as lowest costs and minimal environmental impact.

5. Inexhaustible sources of methane and/or hydrogen from solar and nuclear energy sources represent important potential long-term U.S. options for maintaining and increasing the production and delivery of gas. Therefore, research, development, and demonstration in these energy areas should be continued even though current price projections for their end use are high.

6. Gas-related technologies that improve the efficiency of energy use rank among the most cost effective conservation options. Gas furnace improvements, gas turbines that cogenerate electricity and heat, gas-fired heat pumps, and fuel cells are examples of technologies that make a combination gas supply/conservation strategy very attractive. Replacement cost pricing of gas will reveal that gas options are often less expensive to the nation than other corresponding additional units of energy.

7. Although some of the technologies needed to supply and conserve gas are available today, research should be aggressively pursued to define the production cost and supply potential of unconventional and supplemental gas sources, to improve existing technologies, and to stimulate gas conservation.

8. Environmentally acceptable gas supply and conservation technologies that will sustain or expand gas supplies will be brought to commercial use chiefly when price and other regulatory policies permit. The need for fundamental research is not generally the limiting factor in commercializing most new or improved gas technologies. For near-term technologies and those involving proprietary information, government R&D should be used judiciously; however, in some cases, particularly for R&D into inexhaustible sources and construction of the first coal gasification plants, government support will be required.

SESSION I

U.S. and World Energy Future and the Role of Gaseous Fuels

Charles J. Hitch
Chairman

Scope

This session focused on the U.S. and world energy future and the role of gaseous fuels and, in particular, considered:

- World oil supply
- Uncertainties in domestic energy demand
- World gas supply
- U.S. unconventional gas outlook

Discussion and General Observations

The panel discussed the formidable problems of forecasting energy futures, worldwide and U.S., and of fitting gas into the scenarios.

There was some skepticism of the scarcity scenarios, which, since no one knows what will be discovered, are often based on production from old fields of oil and gas which are inevitably declining. Uncertainties about new discoveries are so great that no one knows or can know, but impending scarcity may remain a "receding horizon" phenomenon since:

- The pace of worldwide drilling is accelerating.
- Worldwide ratios of proved reserves are on the rise.
- New technologies will be available, near term, both in oil shale and in methane.
- The world's economies are slowly adjusting to the 1973-74 shock.

The perception the U.S. is "running out" of oil and gas has led to continued price controls, to such contorted schemes as the Crude Oil Equalization Tax, and to withholding of production by some producers (apparently now including the British). Crying scarcity could become self-fulfilling, but it probably will not. High OPEC-dictated prices make finding new sources of oil and gas very likely.

The major uncertainty clouding this optimistic outlook is the political instability of the Persian Gulf area, which could lead to plummeting prices, or to higher prices through withholding or supply interruptions. Even though scarcity is unlikely, conservation should be practiced in the interest of economic efficiency, and investments in alternative fuels should be made to achieve a greater degree of energy self-reliance and protection from unreliable and monopoly-priced OPEC oil.

On the question of energy demand, it was demonstrated how widely projections of energy demand and use can vary in the long run, depending on one's assumptions regarding GNP (essentially productivity) growth, energy prices, and the price elasticity of demand for energy. For 2025, demand in quads ranges from 127 to 346, depending upon which "reasonable" parameters one chooses. If one also introduces changes in the composition of GNP associated with changed life styles, still lower demand can be projected. In the short to medium run, the ranges are much smaller, e.g., from 92 to 116 quads in 1985.

The energy/GNP ratio is not fixed and has not been fixed over time or across nations or with respect to detailed technology. This does not mean it can change rapidly or harmlessly; energy use is so pervasive and varied that there is great inertia in the short run.

For moderate elasticities of substitution of energy for capital and labor, and moderate decreases in the energy/GNP ratio, Hogan-Manne and others have shown there is little effect on aggregate GNP. But there is now some concern that energy and capital may be predominantly complements rather than substitutes. This would mean that higher energy prices would reduce the rate of return on capital, leading to less capital accumulation, which could have substantial consequences for GNP. But even if this turns out to be the case, it could be offset by, e.g., increased investment tax credits, rapid depreciation, removal of double taxation of corporate profits, etc.

Our most important choice is whether to let markets or the government determine allocations of energy and guide the necessary adjustments to changes in demand and supply. We seem to have chosen the governmental alternative in the case of energy; and, unfortunately, governmental intervention in one energy market often leads to others.

World gas supplies are comparable to world oil supplies. Proved reserves of natural gas are about 2500 quads with annual production of only 50 quads. This R/P ratio of 48 for world gas indicates the latent production potential of gas relative to oil, which currently has an R/P of about 28. Using R/P ratios and finding rates typical of U.S. experience, a capability for doubling or perhaps even tripling current world gas production is not beyond the range of possibility.

The major implications of substantially increased world gas productive capability are twofold: first, that high levels of world gas production will undoubtedly have a moderating influence on the demand for and price of petroleum; and second, that the U.S. should not consider gas imports (i.e., LNG) as additive to total import levels but rather replacement for some oil and therefore should consider the relative benefits to the U.S. of importing some LNG as opposed to all oil. This comparison should include: economics, national security, balance of payments, domestic employment, and environment.

With respect to the U.S. gas supply outlook to the year 2000, the substantial recoverable gas resource base combined with the new gas pricing compromise should result in at least a leveling of lower 48 state gas conventional production at current levels of about 19 Tcf per year. The outlook for supplemental and unconventional gas supplies suggests that up to an additional 5.7 Tcf by 1985 could be produced from increased Canadian imports, Mexican imports, LNG, Alaskan gas, SNG from petroleum feedstocks, coal gasification, and other advanced technologies. By the year 2000, this figure could rise to over 14 Tcf. While such production levels of supplemental gas supplies are clearly possible, a favorable government regulatory and general economic climate is needed in order for these estimates to be fully met. Thus, a capability to supply 25 Tcf of gas (a 25% increase) by 1985 does exist.

While some would question the demand for 25 Tcf of gas in 1985, federal projections suggest large increases (i.e., 50%) in electricity consumption by 1985 with virtually no increases in gas demand/consumption. Given the substantial economic edge that even supplemental gas sources have relative to electricity in most end-use markets, there should be unfulfilled demand for significantly more gas.

Summary

Because the most important reasons for differences in supply/demand forecasts are different assumptions about policies, technology, and mother nature, it is highly unlikely the range of estimates can be substantially reduced.

As for the world, there will be no "gap"--demand and supply will be brought into balance at some price. Prices are going higher; the question is when, not if. The present "surplus" is temporary. We are in a transition from main reliance on oil and gas to other sources, and this will probably take as long as the 60 years required for such transitions in the past--as the one to oil and gas.

As for the domestic supply/demand balance, most of the demand forecasts are in the 90-100 quad range in 1985. This means that a 20 quad increase on the supply side is crucial. With coal and nuclear in trouble, and declining production in old oil and gas fields, the development of new sources of oil and gas is essential. Gas supply will respond to price, leasing policy, and new technology.

SESSION II

Future for Conventional U.S. Natural Gas Supply

David Sternlight
Chairman

Scope

This session focused on the following aspects of the issue of remaining conventional supplies of natural gas in the U.S.:

- The extent of the physically recoverable conventional U.S. natural gas resource base.
- The effect of higher prices on natural gas production.
- The impact on production of accelerated leasing of federal lands.
- The possibilities of additional gas from deep formations.

Discussion and General Observations

Significant additional amounts of conventional gas are recoverable at higher prices and with more rapid federal leasing. This is consistent with estimates of U.S. remaining natural gas resources between 705 to 1189 Tcf. The range of gas production forecasts derived from this resource base reflects differing underlying assumptions about such variables as geological resources, reserves, expected prices, and leasing schedules. The difference made by price and policy assumptions can be seen, for example, in the interpolated MIT Workshop on Alternative Energy Strategies (WAES) forecast of 194 Tcf added to reserves under current policies from 1977 to 1990, and a similarly calculated WAES forecast of 277 Tcf given vigorous U.S. leasing policy and new gas price deregulation.

The Potential Gas Committee of the Colorado School of Mines estimates 1976 proved reserves at 216 Tcf, probable potential supply at 215 Tcf, and possible potential supply at 363 Tcf (total 794 Tcf), as well as speculative potential supply of 345-395 Tcf. The total ultimately discoverable volume of 1139-1189 Tcf (including proved reserves) is located in onshore midwest, the Gulf Coast, and Alaska, with large potential in the east and south as well.

For OCS gas, the Department of Energy (EIA) estimates that under the May 1977 leasing schedule and FPC 770A pricing, based on their mean estimate of 101 Tcf remaining undiscovered OCS reserves, 2.7-2.9 Tcf will be produced from OCS in 1985. In contrast, using the Potential Gas Committee estimate of 150-230 Tcf remaining undiscovered OCS reserves, and similar leasing and price assumptions as EIA, the American Gas Association estimates 4.6 Tcf will be produced from the OCS in 1985.

With accelerated leasing, A.G.A. estimates that 5.2, rather than 4.6 Tcf, could be produced in 1985; with such faster leasing and price deregulation, 5.5 Tcf could be produced in 1985. With more time for response to the accelerated leasing and price deregulation, the effect is even more dramatic. In 1995, OCS production is estimated by A.G.A. as 4.5 Tcf under current policies, and with accelerated leasing and price deregulation, 8.6 Tcf. Total OCS reserves added between 1977 and 1995 would be 90 Tcf, 118 Tcf, and 157 Tcf, respectively, under these same three sets of assumptions--i.e., (1) slow leasing with 770A prices; (2) accelerated leasing with 770A prices; and (3) accelerated leasing with new gas price deregulation.

Based on a survey of major oil companies, the Congressional Research Service reports expected 1985 natural gas production assuming virtually deregulated new gas prices at 16.9 Tcf (compared with an A.G.A. estimate under similar conditions of 20.1 Tcf) and a 1990 estimate of 16.9 Tcf (A.G.A., 20 Tcf). Of the 16.9 Tcf, 65% is expected from U.S. onshore lower 48, 27% from lower 48 offshore, 7% from Alaska onshore, and 1% from Alaska offshore in 1985, shifting in 1990 to 52%, 33%, 9%, and 6%, respectively, supporting the expected shift toward offshore sources. The CRS analysis reflects an addition to reserves from 1977 to 1985 of 130 Tcf, about 191 Tcf to meet production targets through 1990, and an assumption of 180 Tcf of reserves in 1976 in the lower 48 states.

An even more optimistic view is based on new technology improvements and direct experience in the Anadarko Basin. Methane and ethane have been discovered at 31,000 feet; as a result, methane can probably be found to 50,000 feet. Using a Bauxite propping material to fracture tight sands at these levels, production rates from deep wells have been increased from 6 MMcf/day to 20 MMcf/day after fracture. The potential of this undeveloped area from 15,000 to 30,000 feet is estimated to be between 60 Tcf (100% certain) to 300 Tcf (15% certain). A prominent producer in this area believes production rates from Anadarko could be 4-5 Tcf by 1990 and 8 Tcf in 2000. Total U.S. production in 2000 could be 35 Tcf compared with most estimates in the range of 15 Tcf/year. This difference is equal to 10 million barrels of oil per day.

To earn a 15% rate of return, this producer estimates onshore gas above 15,000 feet at $2.00/Mcf and below 15,000 at $4.67/Mcf, assuming a finding rate of 300 Mcf/foot. Deep drilling could be economic at $3.50/Mcf given the potential for discovering more prolific resources at great depths.

Comments and Discussion

Although geological estimates are uncertain, the critical variable in making more gas available is price; the critical policy is deregulation. Higher prices over the past few years have already resulted in increased drilling and reserve additions. In 1977, reserve additions were the highest in ten years.

Substantial gas is available between $1.75/MMBtu and $4.50/MMBtu, the present gap in the supply curve between conventional lower 48 natural gas and supplemental sources. Prices above $1.75 for new gas would allow investments in such possible intermediate supplies as those from the Anadarko Basin--a better value for the country than imported LNG. Price deregulation would also reduce demand and stimulate conservation. The removal of barriers and institutional constraints would attract capital to such investments. It is not capital shortage nor resource limits which impede such investments.

SESSION III

Environmental Implications of Increased Reliance on Gas

Laurence I. Moss
Chairman

Scope

The session was especially concerned with the following environmental aspects of the gas energy option:

- Comparison of gas energy residuals (emissions, effluents) with residuals of alternative sources;
- Assessment of environmental and social impacts; and
- Evaluation of institutional mechanisms to avoid waste of natural resources.

Discussion and General Observations

The remarks of the panelists were generally consistent with the following propositions and policy directions:

Conventional natural gas is generally more attractive, from the environmental point of view, than other fossil fuels. (Some caveats: concern about impacts on certain natural and scenic areas of the Overthrust Belt, impacts of gas pipelines in other areas, etc.)

"Unconventional" gas, although less is known about the impacts associated with its use, may also be relatively attractive with respect to environmental aspects, though problems are often greater than for conventional gas. (Caveats: brine disposal and subsidence from geopressured formations, large number of wells needed in Devonian shales, etc.)

Gas from coal will result in environmental complications associated with the mining of the coal and with the conversion process. For many end-use applications, however, coal gasification may be environmentally more attractive than conventional coal combustion to produce electricity. The social and environmental impacts of coal gasification will be most severe if it uses Western coal, if conversion occurs in arid regions, and if the process produces only gas. The impacts will be least if it uses Gulf Coast lignite, coal from the Midwestern province (except from certain highly productive agriculture lands in central Illinois), or coal from portions of Appalachia; if the conversion takes place in regions with ample water; and if the conversion process is designed to make beneficial use of a high percentage of the available energy in the coal such as with combined cycle generation of electricity and process and/or space heating use of low or medium temperature heat from the turbine exhaust. While ecological damage is possible to rivers in both the East and West with a large coal gasification industry, this is true, perhaps to an even greater extent, with a large electrical generation industry using conventional methods of heat disposal.

"Commercialization" (as distinct from RD&D or first-of-a-kind demonstrations) of coal gasification should not be undertaken if its marginal cost is greater than the market clearing price plus external costs of other comparable forms of energy. It is also true that electrical generating plants should not be built if their marginal costs are greater than the market clearing prices plus external costs of comparable forms of energy. It is not in the national interest to immediately develop, regardless of cost, all possible energy supplies. In fact, perhaps the most useful government action would be a Sherman-like statement to the effect that commercialization will not be subsidized, and that corporate managements are free to succeed or fail on their own. (Similarly, other external costs should be identified and internalized; emission charges are an example.)

On the question of pricing policy in markets with natural monopolies, "rolling in" of high-priced new sources will result in underinvestment in more efficient end-use technology in favor of purchased gas or electrical energy. It also creates an inefficient bias among supply strategies, i.e., in favor of expensive gas supplements and against conventional gas production and coal gasification and cogeneration at the point of end use. In consequence, as overinvestment in even more expensive (to the nation) centralized energy supply than is needed to provide desired goods and services will result. Therefore, the strategy of "rolling in" should be applied, if at all, only as a means of subsidizing first-of-a-kind units using a new technology. In any event, consumers must be given clear signals about marginal costs as well as assurances that near-term subsidies will not prevail over the long term.

Full marginal cost pricing of all supplies of electricity and gas has the problem, under most current conditions, of resulting in collection of more revenue by the utility than would normally be allowed. The excess revenue could be used by government to replace tax revenue (reduction of sales and/or property taxes is a possibility--note the Proposition 13 thrust). In the National Coal Policy Project (NCPP), however, a more modest approach was recommended. It is to determine the revenue to be collected from each major user category (residential, commercial, industrial) using traditional (average) "cost-of-service" criteria, but to then shape the rate structure within each category so that most users pay full marginal cost for at least the last units of their consumption and the units consumed during time of peak demand on the system (this last is generally more important for electricity than for gas).

These propositions and policy directions received further elaboration during the course of the panel discussion.

SESSION IV

Gasification of Non-Renewable Resources--Coal, Oil Shale, Peat, and Other Fossil Fuels

Lawrence E. Swabb, Jr.
Chairman

Scope

The major technical issues related to gasification of non-renewable resources discussed in this session were:

- Fossil fuel resources useful for gasification
- Impact of environmental requirements
- Potential for lower costs from new technology
- Quality of the gasification R&D program
- Commercialization prospects for new gasification technologies

In addition, policy issues such as allocation of water, federal coal leasing, state and local regulations, and government policy on other fuels will also impact on the cost and the timing of the application of gasification.

Discussion and General Observations

Technology per se is not blocking commercial projects for manufacturing gas from coal. Commercially proven technology is available to convert many coals to low and intermediate Btu gas for industrial fuels or chemical feedstocks or to substitute natural gas. Indeed, a commercial SNG plant using Lurgi technology is in the latter stages of planning. This plant is to be located in Mercer County, North Dakota, and will be funded by a consortium of gas pipeline companies. The thrust of the present coal gasification R&D is to extend the capability to gasify a broad range of coals (particularly in the east) and other fossil fuel resources and to lower the cost.

Relatively small research programs are in progress on oil shale and peat. Most of the industry and government R&D funds are being expended on coal gasification surface conversion processes and in-situ gasification. Considering the complexity of coal gasification and the limitation on thermal efficiency, new processes have the potential, at best, of lowering gas costs about 10-15%. Experience with improvements on commercial plant operation may eventually lower costs another 10-15%. In view of this, the government and the gas industry should carefully examine the quality of the gasification R&D program, considering the experience to date, R&D resources, timing and long lead times involved, the probability of technical success, and the probability of commercial application. Consistent development plans are needed which include guidelines and criteria to measure performance and to guide program decisions. A key issue is the question of demonstration plants--when, how many, and which technologies. Some hard decisions lie ahead in the very near future.

Preliminary economics for in-situ gasification indicate a potential for lower gas cost compared to aboveground gasification, but more data are needed to establish a firm cost basis. Good progress is being made in developing this technology, but a commercial-size operation is at least 10-12 years away.

One or two commercial synthetic gas plants based on existing coal gasification technology should be built as soon as possible to provide the technical and economic base of a future industry when it is needed. These first plants will be faced with many regulatory, environmental, and socioeconomic problems, the solutions to which will be applicable to future plants. They will also provide facilities for demonstrating technical improvements at minimum cost and risk.

SESSION V

Advanced Recovery Methods and Unconventional Sources of Natural Gas

James M. Sharp
Chairman

Scope

Session V was directed to an appraisal of three contrasting natural gas sources, each requiring development or improvement of a different technology for successful production:

- Tight gas sands
- Devonian shales
- Geopressured resources

Discussion and General Observations

The emphasis of the discussion was placed on (1) defining the major uncertainties that pertain to the natural gas resource, its economic producibility, the production technology, and potential environmental and social consequences, and (2) identifying that RD&D required to resolve these uncertainties to the point at which the risk of private venture capital for resource exploitation can be determined on a high confidence basis. An obvious high point was a discussion of each of these "unconventional sources" of natural gas in terms of its probable contribution to the supply and reserves of domestic natural gas. Projections of this potential for the three unconventional sources were:

1. Recovery from tight gas sands:
   a. Probable ultimate recovery--150 to 180 Tcf, depending on wellhead price in the range from $1.75 to $3.00/Mcf.
   b. Possible production time scale on an accelerated commercialization basis--2-4 Tcf/year by 1985 rising to 4-8 Tcf/year by 2000.
   c. Major technological improvements required--(1) better location and definition of the producing and adjacent formations, and (2) development of techniques to achieve penetration of hydraulic fractures into all gas-containing parts of a reservoir--particularly lenticular sands in the Western Tight Gas Sands.

2. Recovery of gas from Devonian shales:

    a. Probable ultimate recovery--50 to 150 Tcf at $2.50 to $3.50/Mcf, depending on the improvement of technology and the economic viability of long life/slow return on investment acceptance by large segments of industry.

    b. Possible production time scale--current 150 Bcf/year can be expanded to 2-4 Tcf/year--limited mainly by number of wells drilled and fractured per year.

    c. Major technological improvements required:

        (1) Cheaper fracturing technology capable of contacting larger fractions of gas-saturated shale.

        (2) Fracturing fluids which have minimum deleterious effects on gas flow from shale.

3. Gulf Coast geopressured aquifers:

    a. Probable ultimate recovery--150 Tcf minimum at prices of $3.00 to $4.50.

    b. Production time scale--1-2 Tcf/year by 1995-2000.

    c. Major uncertainties--(1) long-range/large volume hydraulic continuity in the producing formation, (2) natural gas saturations exceeding 50 Mcf/bbl, (3) either beneficial use or economic disposal of produced water, and (4) effective integration of a gas production/thermal-electric power generation or chemical processing system.

SESSION VI

Gas from Advanced Technologies and Renewable Resources

John Foster, Jr.
Chairman

Scope

The focus of this panel's discussion concerned the prospects for producing gas from advanced technologies and renewable resources including:

- Gas from nuclear fusion
- Gas from biomass systems
- Thermochemical production of gas from solar or nuclear fission
- Photochemical production of gas from sunlight

Discussion and General Observations

There are only two truly "renewable" energy sources: solar and nuclear. Neither will last forever. But nuclear energy (fission or fusion), assuming 30 times present energy consumption, can last longer than the billions of years during which the sun will continue to shine.

Some estimate that renewable sources of gas should enter as early as 1995. Even before that date, solar energy in the form of biomass may begin to play a role. Urban and agricultural wastes could give between 5 and 10 quads per year.

Greater amounts could be made available by specifically designed biosystems. Examples of these are desert plants (e.g., euphorbia) with biological characteristics improved by breeding; plants grown on present agricultural lands in off-season; and sea vegetation (kelp and algae, possibly combined with bacterial action).

In the long run, photochemical utilization of sunlight has great promise, although it is not yet known how to realize this possibility. Many small research projects could explore this field in which the main point is to find the right ideas.

High temperatures ($1600^{o}F$) from solar or nuclear sources can be used to produce hydrogen by one of several thermochemical routes. This possibility is now being nursed more intensively in Europe than in the United States.

A relatively small solar unit has been proposed which could produce hydrogen for \$7.50 to \$10.00 per 10^6 Btu, assuming the goals for collectors are met. This project would put to a useful test high-temperature production through the use of moving solar mirrors. The proposal provides for more flexible use of solar energy than solar electricity generation.

Laser fusion, which is a relatively recent version of controlled fusion, could serve as a good source of high-energy neutrons to drive gas-phase reactions to produce fuel. There is no unanimity about the eventual economic feasibility of this proposal. That some form of nuclear energy will make contributions in the long run seems likely.

Some studies have concluded that renewable resources may not be in urgent demand before 2025. Actually, predictions for the next half century are difficult. Half a century ago, nobody had proposed the use of nuclear energy. Consumption of gas and electricity was a fraction of the present rates. Indeed, one may argue that if the U.S. can wait until 2025, then the use of coal deposits could sustain a reasonable demand for an additional one or two centuries.

The use of coal, or any other fossil fuel, is coupled, however, with the uncertain effects of increased carbon dioxide in the atmosphere. Population increase and the demand for more per capita energy in the developing countries would indeed lead to an increase of carbon dioxide which acts as a thermal blanket.

The consequence may be an increase in the average temperature. It may be more important that the temperature increase near the low heat capacity polar regions could be much more substantial than the temperature increase in the tropics. The consequences of this change in temperature distribution is unknown. In fact, the whole CO_2 question is characterized by substantial ignorance.

In view of potential changes in climate and in view of the difficulty to place a worldwide limitation on the burning of fossil fuels, reliable information on the effect of CO_2 is urgently needed. It is suggested that a determined effort be made to predict this "greenhouse" effect in a reliable manner.

In case the U.S. cannot rely on fossil fuels, the remaining energy source is geothermal heat. Only the "fossil heat" in the top six miles of the earth crust is potentially available. This energy is comparable to the energy contained in coal. But the characterization of this resource and its use are only partially explored.

Conclusions and recommendations drawn from these discussions include the following:

- There is an urgency to determine through basic and applied research the economics, potential environmental effects, technical feasibility, and expected timing for commercial application of the more promising technologies for gas production.

- Appropriately scaled technology applications, such as the production of methane from biomass, should be vigorously pursued where local economics and/or supply security requirements allow.
- A very aggressive effort should be undertaken to understand the effects of CO_2 as their impact may affect the time when advanced technologies which produce less or even ultimately utilize CO_2 may be required.

SESSION VII

Conservation and Improved Gas Utilization

Roger W. Sant
Chairman

Scope

This session was concerned with conservation and improved utilization of gas and considered such topics as:

- Pricing of new supplies to stimulate investments in more efficient end-use technologies.
- Efficiency of end-use gas technologies versus those utilizing other forms of energy.
- Decentralized gas technologies including solar augmentation.

Discussion and General Observations

Energy conservation should be viewed as the substitution of technology for energy use that results in the same service being supplied for a lower amount of energy consumption. In that context, several concepts and conclusions were emphasized by the panel:

1. Conservation technologies must be equal to or less than the cost of the energy saved in order to get a share of the energy services market.
2. New increments of all types of energy must be priced to reflect their replacement cost so that conservation technologies can compete equally with supplies in the marketplace.
3. Many gas-related conservation technologies are among the most cost effective means of supplying energy requirements. These include gas furnace retrofit, gas turbine cogeneration, gas-fired heat pumps, and fuel cells, all of which deserve greater emphasis.
4. A combination gas supply/conservation strategy deserves more emphasis in national energy policy because it will likely result in lower energy costs to the consumer and reduced environmental degradation.
5. Gas utilities could, and probably should, for their own benefit provide a major marketing impetus for several of the most effective conservation technologies. This could

come from either direct sales, leased units, or utility-owned equipment sold on an energy basis.

6. There are large differences in the way conservation technologies can be utilized. These range all the way from selling more efficient small appliances to consumers to large gas turbine cogeneration systems in industry. This dispersed energy market creates a need for understanding the commercialization requirements as these technologies are further developed.

7. Gas may provide the most attractive means of making a long-term transition to a solar economy. Decentralized gas using devices that provide both electricity and space heating and cooling, can be easily augmented by solar technologies as these become available, and will substantially increase efficiency in the interim period.

SESSION VIII

Commercialization and Energy R&D Policy

Robert W. Fri
Chairman

Scope

This session, which built upon the previous seven sessions, was primarily concerned with:

- What gas-related R&D is needed.
- What the federal role should be in research and in demonstrations.
- What are the other nontechnological barriers to commercializing new technology.

Discussion and General Observations

On the basis of the discussions during the preceding seven sessions, it was concluded that:

- Gas is a generally desirable fuel.
- We no longer think of gas as a scarce fuel, but as one in potential abundance.
- To realize this abundance, it is important to deploy technology, not simply to do R&D.
- Fortunately, much of the technology the gas industry needs is already in hand--e.g., for conventional gas, LNG, SNG, and pipelines. Nothing needs to be invented to exploit unconventional resources, although some well understood research is required. Conservation technologies follow similar patterns.
- Thus, gas industry R&D needs are fairly straightforward and, for the most part, inexpensive.
- Unfortunately, there is a technology gap between cheap conventional gas production and expensive supplemental sources such as LNG and Alaska gas. Unconventional resources may close this gap.
- The most important decision for gas technology is to specify the markets in which the industry will compete. It seems sensible to:
  a. Serve the residential, commercial, and high-priority industrial market, including the displacement of foreign oil.
  b. Once supplies for the above market are secured, compete for lower priority uses.

These conclusions lead to clear-cut R&D and commercialization priorities:

1. Employ known supply and conservation technology as rapidly as possible to supply priority markets. Only targeted process improvement R&D is needed, and should be industry funded.
2. Rapidly complete R&D on unconventional sources to establish reserves, production potential, and costs.
3. Continue to support research into exotic sources, largely through federal funding.

It was generally agreed that:

1. A stable regulatory environment, and particularly prices that reflect production costs, is the key to deploying known technologies and commercializing new ones.
2. Federal support of conservation R&D is adequate, and the gas industry can get its share.
3. Although R&D in unconventional sources should be accelerated, industry should be wary of inviting government participation.

As a general rule, government is inefficient in conducting demonstration and applied development projects. It was proposed that the DOE should disengage from direct participation in pilot and demonstration projects, and instead offer only a limited subsidy of product prices to attract industrial projects.

The central issue remains whether and how the government should support coal gasification projects. Four rationales for this support were offered:

1. It is the least attractive of gas sources, but it is certain to produce abundant gas. Therefore, one or more plants should be built to gain information on coal gas.
2. It is the best option for using coal, and thus deserves priority over other coal-based projects.
3. It is needed to serve existing customers through distribution systems already in place.
4. It is needed to expand gas markets.

Although any of these justifications might support demonstration of coal gasification, it was noted that:

1. Congress believes that the need to supply existing markets is the best justification.

2. To assert that gas is potentially abundant undermines this justification.

3. If a new justification is to be used, it should be carefully introduced.

PARTICIPANTS IN THE ASPEN INSTITUTE WORKSHOP

on

R&D PRIORITIES AND THE GAS ENERGY OPTION

Aspen, Colorado - June 25-29, 1978

Session I - U.S. and World Energy Future and the Role of Gaseous Fuels

Chairman:	Mr. Charles J. Hitch, President Resources for the Future
Discussion Leaders:	Dr. Arnold E. Safer Vice President, Economics Irving Trust Company
	Dr. Lester B. Lave Professor of Economics Carnegie-Mellon University
	Dr. William T. McCormick, Jr.* Vice President, Policy Analysis and Government Relations American Gas Association
Respondent:	Mr. Eric R. Zausner, Vice President Booz Allen Applied Research

Session II - Future for Conventional U.S. Natural Gas Supply

Chairman:	Dr. David Sternlight, Chief Economist Atlantic Richfield Co., Inc.
Discussion Leaders:	Dr. Herman Franssen Director, Market Analysis Office of International Affairs Department of Energy
	Dr. Harry C. Kent Director, Potential Gas Agency Colorado School of Mines
	Mr. Robert A. Hefner III, President GHK Corporation
Respondent:	Dr. Richard Gonzales Consulting Economist

* Presently Vice President and Assistant to the Chairman, American Natural Service Company.

Session III - Environmental Implications of Increased Reliance on Gas

Chairman:	Mr. Laurence I. Moss Environmental Consultant
Discussion Leaders:	Mr. Gerald Decker DOW Chemical Corporation
	Dr. Ron Erickson Director, Environmental Studies Program University of Montana
	Philip J. Mause, Esq. Attorney-at-Law
	Bruce J. Terris, Esq. Attorney-at-Law
Respondent:	Dr. John H. Gibbons Director, Environment Center University of Tennessee

Session IV - Gasification of Non-Renewable Resources - Coal, Oil Shale, Peat, and Other Fossil Fuels

Chairman:	Dr. Lawrence E. Swabb, Jr., Vice President, Synthetic Fuels Research Exxon Research & Engineering Co.
Discussion Leaders:	Mr. Harry Perry, Consultant Resources for the Future
	Dr. S. William Gouse, Chief Scientist The MITRE Corporation
	Dr. Kenneth Street Associate Director for Fossil Energy Programs Lawrence Livermore Laboratories
Respondent:	Mr. Eric H. Reichl, President Conoco Coal Development Company

Session V - Advanced Recovery Methods and Unconventional Sources of Natural Gas

Chairman:	Dr. James M. Sharp, President Gulf Universities Research Consortium
Discussion Leaders:	Mr. Lloyd Elkins Petroleum Consultant
	Mr. William F. Morse, Director of Research Columbia Gas System Service Corp.
	Prof. Myron H. Dorfman Director for Geothermal Studies University of Texas
Respondent:	Dr. Lincoln F. Elkins Technical Advisory to General Manager Sohio Petroleum Company

Session VI - Gas From Advanced Technologies and Renewable Resources

Chairman:	Dr. John Foster, Jr. Vice President and General Manager Energy Systems Group TRW, Inc.
Discussion Leaders:	Dr. Melvin K. Simmons, Assistant Director for Analysis and Assessment Solar Energy Research Institute
	Mr. G. M. Farbman Westinghouse Electric Corporation
	Dr. Henry J. Gomberg, President KMS Fusion Inc.
Respondent:	Dr. Edward Teller Associate Director Emeritus Lawrence Livermore Laboratories

Session VII - Conservation and Improved Gas Utilization

Chairman:	Mr. Roger W. Sant, Director, Energy Conservation Policy Center Carnegie-Mellon Institute of Research
Discussion Leaders:	Dr. Gene G. Mannella, Vice President, Research and Engineering Institute of Gas Technology
	Dr. Robert C. Weast, Vice President, Research Consolidated Natural Gas Service Co., Inc.
	Dr. Barry Commoner, Director, Center for the Biology of Natural Systems Washington University (St. Louis)
Respondent:	Mr. Frank M. Potter, Jr., Staff Director, Subcommittee on Energy & Power House Committee on Interstate & Foreign Commerce

Session VIII - Commercialization and Energy R&D Policy

Chairman:	Mr. Robert W. Fri Consultant
Discussion Leaders:	Dr. Daniel A. Dreyfus Deputy Staff Director for Legislation Senate Committee on Energy and Natural Resources
	Dr. Philip C. White Consultant
	Dr. Bernard S. Lee, President-Elect Institute of Gas Technology
Respondent:	Dr. Robert A. Charpie, President The Cabot Corporation

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American Gas Association

February 29, 1980

DOE FY81 BUDGET ANALYSIS

The proposed DOE budget for FY81, excluding funds for the strategic petroleum reserve and energy security reserve, totals $10.25 billion, an 8.3% increase over the FY80 budget of $9.47 billion. Further comparision with FY80, as shown on Tables I and II, reveals that DOE has shifted their priorities, placing new emphasis in the catagories of Conservation and Research, Development & Applications.

The largest increase in any major program category occurred in the Conservation budget, a 30.9% increase over FY80. This is the result of increased grant programs to State and local governments, energy impact assistance programs and a new $50 million public education advertising campaign. Conservation research and development funding for FY81 is unchanged from FY80.

The FY81 Research, Development and Application budget increased only 9.7% compared to FY80. However, there was a change in emphasis within this catagory with the Fossil Energy budget increasing 29.9% to $1.165 billion while Nuclear Fission decreased 22.0% to $925 million. The Fossil Energy increase is primarily due to funding for three synthetic fuel demonstration plants, SRC I and II and one high-Btu coal gasification plant. These three demo plants account for $461 million or 39.6% of the total Fossil Energy budget.

In addition to the high-Btu coal gasification demonstration plant funding, the Fossil Energy budget changes as follows: 1) surface coal gasification research is up 18.2% with the biggest increases in peat gasification and third generation process research; 2) in-situ coal gasification unchanged and 3) enhanced gas recovery down 13.6% primarily in environmental research.

The Solar Applications and other Renewables budget contains the biomass and geopressured resources funding. The total biomass budget for both land and marine biomass is approximately $13.1 million for FY81. The geopressured budget is unchanged from FY80 at $36.0 million. The total biomass and geopressured budget of about $51.0 million represent only 5.9% of the total Solar and Other Renewables budget.

In an effort to determine that portion of the DOE FY81 budget which is dedicated to the gas industry, Tables III and IV were developed. Although the gas industry continues to provide approximately 25% of the total energy consumed in the United States and approximately 33% of domestic U.S. energy production, gas receives only 5.1% of the DOE FY81 budget. Electricity, by contrast, receives 43.6% or a ratio of almost 9 to 1 compared to gas. The Research Development and Applications budget reveals similar results with gas receiving 8.5% of the budget while electricity receives 77.6%, again a ratio of approximately 9 to 1. The disproportionately small share of the DOE FY81 budget which is dedicated to the gas industry does not represent the current or potential contribution to the national energy mix which gas can and will provide.

AMERICAN GAS ASSOCIATION 1515 Wilson Boulevard, Arlington, Va. 22209

Table I

DOE Total Budget
FY81 vs. FY80

Major Program Categories	$ MM FY80	 FY81	% Change
Research, Development & Applications	3,730	4,092	9.7
General Sciences	472	523	10.8
Conservation	815	1,067	30.9
Regulation and Information	379	355	(6.3)
Defense Activities	3,008	3,443	(14.5)
Direct Energy Production	488	408	(16.4)
Department Administration	275	362	31.6
Legislative Proposal - Spent Fuel	300	---	---
Subtotal	9,467	10,250	8.3
Energy Security Reserve	2,208	0	---
Strategic Petroleum Reserve	0	2,404	---
TOTAL	11,675	12,654	8.4

Table II

DOE Research, Development & Applications Budget FY81 vs. FY80

Research, Development & Applications	$ MM		% Change
	FY80	FY81	
Fossil Energy	897	1,165	29.9
Solar & Other Renewables (1)	771	868	12.6
Electric Energy Systems & Storage	104	112	7.7
Magnetic Fusion	356	404	13.5
Nuclear Fission	1,186	925	(22.0)
Environment	235	261	11.1
Supporting Research	252	297	17.9
General Purpose Facilities	---	60	----
General Reduction	(71)	---	----
TOTAL	3,730	4,092	9.7

(1) Includes wind, ocean, biomass, geothermal and geopressured

Table III

DOE Total FY81 Budget
By End Use Categories

Major Program Categories	$ MM Gas	 Electric	 Other	 Defense	 Total
Research Development & Applications	248	3,177	567	0	4,092
General Sciences	0	474	49	0	523
Conservation	72	94	901	0	1,067
Regulation & Information	85	170	100	0	355
Defense Activities	0	0	0	3,443	3,443
Direct Energy Production	0	408	0	0	408
Department Administration	18	147	71	126	362
Subtotal	523	4,470	1,638	3,569	10,250
% of Subtotal	5.1	43.6	16.5	34.8	100.0
Strategic Petroleum Reserve	0	0	2,404	0	2,404
TOTAL	523	4,470	4,092	3,569	12,654
% of Total	4.2	35.3	32.3	28.2	100.0

Table IV

DOE Research, Development & Applications Budget By End Use Categories

Research, Development & Applications	$ MM			
	Gas	Electric	Other	Total
Fossil Energy	217	664	284	1,165
Solar & Other Renewables	51	623	194	868
Electric Energy Storage Systems	0	112	0	112
Magnetic Fusion	0	404	0	404
Nuclear Fission	0	925	0	925
Environment	38	182	41	261
Supporting Research	37	220	40	297
General Purpose Facilities	5	47	8	60
TOTAL	348	3,177	567	4,092
% of Total	8.5	77.6	13.9	100.0

STATEMENT SUBMITTED FOR THE RECORD

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

FY'81 DOE BUDGET FOR THE HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

DONALD J. BLICKWEDE
VICE PRESIDENT OF BETHLEHEM STEEL CORPORATION
AND
CHAIRMAN OF HTGR PROCESS HEAT USERS GROUP

APRIL 1, 1980

STATEMENT SUBMITTED FOR THE RECORD

Mr. Chairman, my name is Donald J. Blickwede. I am Vice President and Director of Research for Bethlehem Steel Corporation and Chairman of a recently formed HTGR Process Heat Users Group. I am pleased to have the opportunity to be here today to express support for the HTGR Program.

The HTGR as an optional energy source was initiated by the American Iron and Steel Institute in 1974. An AISI study group found that a process employing the HTGR to produce a synthesis gas from coal, which could be used to reduce iron ore to iron, was technically and economically feasible. Accordingly, in 1976 we recommended to ERDA that development of the very high temperature gas cooled reactor (VHTGR) be included in their program.

The new Process Heat Users Group was organized about a year ago. Representatives from steel and gas utility companies are on it as well as glass chemical and oil companies. The primary interest of our Group is to identify the end requirements for the HTGR Process Heat plant in order to better guide the design and development activities.

With the depletion of domestic oil and gas resources and the increasing threat to U.S. security and economic well-being imposed by reliance on foreign energy imports, new energy resources based on coal and nuclear energy will be needed for industrial applications in the future. The HTGR is the only nuclear concept with the high temperature capabilities necessary for many industrial applications. In this regard, I would like to add user prespective to the need for the HTGR as an option.

To illustrate the incentives for industrial interest in the HTGR, let me first summarize the international activities and some specific process heat applications.

International Activities

The use of an HTGR as a process heat source has received considerably more emphasis abroad than it has to date in the U.S. This is possibly because of the more urgent needs heavily industralized countries like the Federal Republic of Germany and Japan have for non-fossil heat sources. The most substantive foreign HTGR process heat program exists in the FRG. In the FRG, coal is the only fossil energy resource available within the country, and the generation of synthetic natural gas (SNG) from coal by utilization of heat from HTGR's is the primary goal of their nuclear process heat program. The Federal Republic of Germany has invested approximately $1.4 billion in development of high temperature gas-cooled reactor technology since the inception of the program and spent $250 million during 1979, with about the same level of effort expected during 1980.

Japan's HTGR process heat effort has just completed its initial phase, which was a seven-year program begun in 1973 to develop the technology for steelmaking embodying an HTGR. The Japanese efforts have included the design and development of a 50 MWt prototype Very High Temperature Reactor (VHTR) as well as heat exchangers and a high pressure direct reduction process. The Japanese have invested about $100 million to date on HTGR development.

Many major industrial processes require large amounts of heat at high temperatures. One class of such processes utilize steam. Examples are chemical plants, paper plants and petroleum refineries. Another important high temperature heat process is reforming, by which water is reduced to hydrogen.

Process Steam/Cogeneration

The HTGR for Process Steam/Cogeneration applications is based upon steam cycle technology and, hence, may be considered current state of the art. Principal barriers to deployment are institutional (commercial risk, regulatory issues, siting, utility/user contract, etc.) rather than technical in nature. Since process steam can be economically transported only over short distances (approximately 10-20 miles), the reactor plant must be located near to the point of use. Hence, the Process Steam/Cogeneration Plant is best utilized in areas where large chemical or industrial facilities are located. A specific example recently studied by

ORNL is the Gulf Coast industrial area within which major petrochemical facilities are located. In the ORNL investigation, various means of replacing existing oil and gas fired capacity were studied, with process steam and cogenerated electricity being the products of interest. A significant savings was projected for the HTGR relative to repowering with coal.

Reforming

While Process Steam/Cogeneration can replace small amounts of current gas and oil fired capacity, the key to large scale industrial replacement of fossil energy resources by nuclear power is development of HTGR systems in which reactor thermal energy is used to produce a gaseous mixture of carbon monoxide and hydrogen from water and a hydrocarbon (e.g., coal). In effect, this process creates a storable, transportable, gaseous chemical which has a multitude of uses in the industrial sector. As a feedstock it can be used for synthetic fuels production, fertilizer production, methanol production and as a reductant for iron ore. Use of nuclear heat for reforming can reduce coal requirements from 20 percent to 40 percent.

When used as a substitute fuel, the synthesis gas may be transported to a remote location and the reactor heat recovered through the reverse chemical reaction (methanation). The resulting thermal energy may be used directly or may be used to generate steam for industrial processes, electricity generation, or a combination of the two (cogeneration). In open cycle systems, the methane resulting from the reverse chemical reaction is locally utilized as substitute natural gas (SNG). In closed cycle systems (thermochemical pipeline), the methane and water returned to the reactor for reuse in the reforming process.

From the industrial viewpoint, the implications of reactor heat stored in a transportable form are very significant. When used as a storable/transportable fuel substitute, the synthesis gas can be transported great distances and can be stored for long periods, thus overcoming the principal difficulties associated with Process Steam/Cogeneration technology. Further, in the long term, distribution can be made to smaller industrial users as well as large.

Recommendations

Reflecting our conviction that HTGR development is vital to U.S. industry, and believing that a Lead Project is the most acceptable path to development, the Process Heat Users Group offers the following recommendations for FY 1981:

1. We endorse the establishment of an aggressive Lead Project targeted for operation by the mid-1990's.
2. The present Base Technology program should be continued.
3. The long-term HTGR Program should include development of Process Heat applications.
4. Maximum benefit should be derived from the aggressive Process Heat programs in Europe and Japan; however, the U.S. program should be capable of self-sufficiency.

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STATEMENT OF CALIFORNIA SYNFUELS

Concerning

S. 2332: TO AUTHORIZE APPROPRIATIONS FOR THE DEPARTMENT OF ENERGY FOR FISCAL YEAR 1981

INITIAL SUMMARY

As the Committee considers a broad range of initiatives designed to assist the nation in achieving energy production adequate to sustain satisfactory national economic growth rates in the twenty first century, we urge that it make provision for an important element in successfully negotiating the 1980's and 1990's — efficiently converting to highly valued fuels the increasingly thick and viscous, or "heavy", oils and oil-like substances which we encounter as domestic reserves of lighter oils are depleted.

"Heavy oils" and tar sands materials are expected to contribute several hundreds of thousands of barrells per day to our domestic petroleum supply in the 1980-2000 period. Today the production from California alone is estimated to exceed 300,000 barrells per day.

But our domestic refinery stock is ill equipped to convert extremely heavy oils to useful fuels. Today about 200,000 barrells per day of Alaskan oil bypasses West Coast refineries unable efficiently to process these relatively heavy oils, to be processed in Gulf and Caribbean units, while we import 650,000 barrells per day of foreign crudes for our West Coast refinery stock.

Improvements on refining techniques now in use may be expected to improve our capacities to produce fuels from existing feedstocks, and to enable refineries to handle somewhat heavier feedstocks. But there are limits to the extent to which existing refining techniques can be pushed, and a lack of commercially demonstrated technology of the sort tailored to converting vacuum residues and extremely heavy oils as initial feedstocks into a highly valued slate of products of the sort which will fuel the prime movers for automobiles, trucks, and electricity generating stations.

We urge the Committee to follow on $2 millions appropriated in 1979 for fiscal year 1980 in order to start work in the heavy oils conversion area, by including in its authorization for Fiscal year 1981 funds in sufficient amount to see to completion a project now under way to demonstrate a technology which will, if as successful at commercial scale as in pilot tests, contribute materially to our capacity to (1) make better use of residual oils remaining after conventional refining processes and very heavy crudes in the 10 API range and below, and (2) produce and pipeline very heavy oils and tar sands materials. Any such authorization may be conditioned DOE being satisfied not only with the over-all concept of the project, but also with the adequacy of engineering work, and the costs and projected viability of the project.

THE NATURE OF THE HEAVY OIL PROBLEM

Placed on a scale which reflects ease or difficulty of extracting and converting valuable use sources of energy, "heavy oils" and tar sands materials may be considered as a segment in the spectrum of hydrocarbon materials intermediate between the light oils on which we have relied principally in the past, and the coals on which we expect to rely so heavily in the future.

There is a lack of awareness about the size and importance of this resource.

Current estimates put the amount of heavy oil in place in the United States at 110-125 billion barrells. We now estimate about 30 billion barrells of tar sands materials. Canada has tar sands materials with hydrocarbon content in the trillion barrell range. Canadian heavy oil reserves are not as yet estimated with any precision -- the National Energy Board talks in terms of a few billion barrells, others of over 60 billion barrells recoverable. Venezuela is estimated to have over 600 billion barrells of heavy oils.

Worldwide, there may be as much "heavy oil" in place as there is light oil, of the kind we have ben tapping. And there may be this amount or more in tar sands materials.

While there are huge quantities of "heavy oil" and tar sands materials in being, there are also major problems in recovering and using these materials. About 18% is the highest current estimate of recovery of U.S. domestic heavy oils. This percentage may go up, of course. But it will do so only as technology improves, and, probably, prices go higher signalling greater investment in the effort.

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There are several problems involved in recovering and using "heavy oils". The first is in freeing the hydrocarbon materials from their surroundings: the materials are by definition those which do not flow freely into boreholes.

But this is only the beginning. We currently burn the heavy oils to generate heat to free up the heavy oil. But this creates air pollution. A recent CRS study indicates that in Kern County California heavy oil recovery operations generate emissions at a rate of about 250 tons of sulfur dioxides, 120 tons of nitrogen oxides, and 23 tons of particulate matter per day; merely from generating steam to feed the wells.

Then there is the problem of pipelining the materials. The very heavy crudes and tar sands materials will not flow in pipelines at ambient temperatures. This has, to date, meant that we either heat the pipeline, dilute the material, or introduce viscosity reducing materials to the heavy oil. Each alternative costs.

Once the materials reaches the refinery, there is another major problem. A recent CRS study pointed out that "There are relatively few refineries in the world that can process substantial amounts of heavy crude oil", referring to the report of a working group on this topic assembled at a recent international conference on heavy oils. A report to the Congress on United States refining policy of June 1979 recommended

> To the extent that capital investment in new refinery policy is encouraged by U.S. policy, efforts should encourage the development of additional conversion capacity to refine heavy sour crudes as light sweet crudes, traditionally relied upon, become less available. (p.ii)

As noted in the summary, this is a severe problem today. In the Western United States, the "residual" fraction of refinery runs is now over 20%, over twice the national average of 10%; and rising.

With the decontrol of oil prices, heavy oil production in California in increasing. Estimates now range between 300,000 and 500,000 barrells per day, with the industry asserting that it could produce a million barrells per day if environmental controls were eased. But the California rrefinery stock simply can't handle this output efficiently.

We are currently importing over 600,000 barrells per day of crude oil of the sort the refineries can handle efficiently in the Western U.S.. About 200,000 barrells per day of Alaskan oil bypasses California refineries for the expensive ride through the Panama Canal to Gulf refineries because the California refineries cannot take a larger burden of relatively heavy and sulfur rich crude, given the California production and their limitations.

If there had been no OPEC, we would have moved through this spectrum of materials and confronted these problems gradually, drawing on lighter foreign oils to an increasing extent before we turned to heavier domestic resources for substantial production. But the coalescence of the OPEC nations on a strategy of relatively sudden large price increases for their crude oils, simultaneously increasing our balance of payments burden and leading us to look for domestic resources which may be drawn on stream advantageously at the nigher prices, has had the effect of forcing us to telescope our evolution in energy supply development.

As the summary above indicates, California and Alaska are the leading edge of a problem which confronts us over the nation as a whole, the Western hemisphere, and indeed the globe. We are going to need to deal efficiently with heavy oils and tar sands in several districts of the United States, in Canada, and in Latin America.

The more rapidly we do develop efficient techniques for making highly valued products out of such materials, the more rapidly will our national (and international) inflation and productivity problems abate. This is simple fact, none the less simple or inescapable for it being so large and consequential. The need for acceleration of the private market response is as sharp here as in the coals, or other synfuels, or or other energy development areas.

THE PROBLEM OF ORGANIZING PUBLIC ACTIVITY

The thrust of the massive federal effort to "accellerate" bringing on-line new supply technologies means, in this context, stimulating movement into and through this intermediate segment, and into the coal based segment of the hydrocarbon supply chain, more rapidly than we expected at the outset of the 1970's. The government is in effect forcing the pace of the evolution of production techniques for dealing with the heavyoils/tar sands/shale oil resources, as well as the coal (and other) resources.

But the government response has thus far been quite fragmentary, and not dealt at all with major parts of the problem.

At the production level, the federal government has been supporting additional work in "enhanced oil recovery" for some years now, by a variety of means. In addition, the recent decontrol of prices is allowing market forces to evoke supply more fully than would be the case were price controls continued.

However, almost nothing has been done with respect to the other problems involved in making use of heavy oils. The pipelining problem is recognized, but has not been addressed. Little has been done at the technical level to deal with the environmental problem. Nothing has been done at the refinery level.

It is not enough to observe that there are incentives for private industry to deal with this problem. The private market is lagging the situation. The nation is squeezed on energy prices, is trying to become more efficient in fuel use, and is undertaking to accellerate supply development. (With some justice, private industry can observe that government controls in this country and government actions in the OPEC countries may be major factors in its being so mispositioned. We would prefer not to have to carry the burden of determining the merits of the policies of the private and public bodies in this connection at this point. The facts are that we are in the difficult position described.)

We could make progress on the heavy oils/tar sands segment of the supply chain more rapidly than the coal segment. The technologies which might be used are closer to existing technologies, and development of new techniques could proceed more rapidly, with less expense, than in the coal conversion area.

But the federal funding establishment is so ponderous and often disjointed that it tends to frustrate its own objectives.

The technology which HRI and California Synfuels wish to demonstrate is a case in point.

This technology addresses each of the major problems involved in developing and making good use of the heavy oil resource; and can make a contribution to getting more out of the light oil barrell as well.

At pilot plant scale, the process demonstrated an ability to make a total conversion of extremely heavy crudes and residuals into gasoline feedstock, boiler grade gas, and distillates which can be converting into motor fuels or heating oil; with no significant emissions to the environment and no unusable residues.

In other words, in a world in which "There are relatively few refineries ... which can process substantial amounts of heavy crude oil...." this process would, once proved at commercial scale, introduce a capacity for processing large amounts of heavy crude oils efficiently, into highly valued products, with no significant adverse environmental consequences at the appeared to be an highly promising approach for helping realize much of that potential. But a policy against "refinery" projects prevented organized DOE action on a proposal to demonstrate the technology at small commercial scale.

Congress passed a two million dollar appropriation to start DOE work on heavy oil conversion in late 1979. It also passed a 2.2 billion loan guarantee authorization for "alternative fuels". But the major "alternative fuels" funding program excluded any work on petroleum projects, and thus excluded heavy oils.

In 1980 Congress seems to be heading toward including work on heavy oils in the scope of the Energy Security Corporation. This would plug the gap left by the 1979 appropriation. But ESC will not be on stream until 1981, and its funding will not begin to get into projects until middle or late calendar year 1981, or 1982.

This situation left DOE with some funds to start work in the heavy oils area in FY 80, but no funds with which to pursue in FY 1981 any promising initiatives or projects. By the time the FY 1980 appropriations were passed, DOE was far along in its FY 1981 budget work-up, and had nothing in that budget contemplating follow-on of the work which Congress was then mandating in heavy oils conversion.

The net effect has been that though Congress had expressed interest in pursuing work to accellerate supply development in the heavy oils conversion area, both the DOE and the synfuels budgeting processes have thus far allowed a gap of a fiscal year in which any initiatives which are begun could founder.

There are problems in the DOE contracting process. Though a proposal was presented in January, no decision has been made to proceed with the two millions appropriated for FY 1980. We understand that the DOE staff seem to favor investing the two millions in the project. But they have no follow on money. Further, though they are surely sympathetic to what CalSyn and its joint venturers are trying to do, and numerous staff people have made some contact with the principals, the DOE staff group have not yet gotten involved in the project with the degree of intimacy which signing a contract and reviewing progress entails. In our opinion, they may not be fully aware of how far project engineering has gone with private funds to date.

So at a time when Congress must decide on follow-on funds to meet the private parties's timetable, DOE staff can advise on basic project merit in directional terms -- it seems to have basic merit in terms of direction and concept -- but seem unable to advise fully on all aspects of the project.

The situation described above presents all concerned with a gap in the federal involvement which could frustrate the objectives of both the private parties and the Congress in seeking to stimulate useful liquid fuels supply.

ACTION NEEDED

Most of the pieces needed effectively to put public energies behind efforts to deal with key problems in developing heavy oils either are or soon can be put in place.

As noted before, to that portion of this problem which is most immediately before us, DOE has before it a proposal to demonstrate a technology designed to deal with the processing bottleneck as to a key portion of the hydrocarbon supply chain, in an environmentally acceptable manner. Funding for initial stages of the project is in place.

Longer range, the Synfuels bill appears likely to allow for any follow-on project or alternative approaches which may later be thought to be useful.

The missing link, literally, is FY 1981 funding for DOE to see the first demonstration project into the construction phase. If the government wishes private parties to pick up most of the cost of this project, the private parties must know that the government money is available for commitment in late 1980 and in calendar 1981, if the project engineering, cost estimates, and project management are all found suitable at the time the money is to be committed for construction. If the government cannot move on this time frame, and wishes to study the project for a year, then it must face the prospect that its delays will discourage private participation and be prepared to pick up most or all of the cost of any project which might be consummated.

There are three possible solutions to this problem.

1. Congress could include sufficient funds in its FY 1981 DOE authorization and appropriation action to support the construction scheduled for FY 1981. Given that there has not been as much time for DOE review and involvement as is often the case, this authorization should both call upon DOE to expedite its contracting process on the project and make clear to DOE that if it is not satisfied with cost and other relevant data developed in its work with the project, including the data developed by commitment of the initial $2

millions, it is not obligated to spend the full sums authorized.

A variation on this approach might also have merit. Congress could authorize loan guarantee funds under or otherwise suggest to the Appropriations Committee that it make available funds to DOE under the Department of Energy Act of 1978, P.L. 95-238, 92 Stat. 47, adding a new Section 19 to the Federal NonNuclear research and Development Act of 1974, for a loan guarantee for the project. Under this plan, the decision point for DOE on the loan guarantee could be set for the time the private firms commit their own construction money. This would be later this year.

2. Congress amends P.L. 96-126 to allow for use of parts of the $2.2 billions appropriated therein on heavy oil upgrading demonstration projects. If this were done the amendment should probably make clear that R&D projects only are envisaged: we doubt that DOE would find attractive getting involved in numerous oil and gas refinery projects. Also, the amendment would need to make clear that funds could be committed for an unsolicited proposal now before DOE, so that this project, allready under review and with funds usable for starting it, could be picked up smoothly in accord with timing needs.

3. Congress might insert a provision in S. 932 to the effect that heavy oil project which would be eligible under its criteria now pending before DOE could be funded by DOE with funds appropriated in P.L. 96-126. This should also recognize that the hand-off of the project to this funding source should be smooth and allow for timely action.

Of these three courses of action, the first is clearly the most straightforward. It also provides a clear signal to the private parties that Congress is interested in participating in the project, if DOE staff are fully satisfied with the merits of the project at the same time the private parties have to make their own commitments. In effect, Congress would be requiring of DOE that it do its homework as rapidly as the private parties, as to construction commitments, and be prepared to commit at the same time. The private parties know the money is available if all are ready to commit it. This is very important for the project. But also implicit in this arrangement is the same escape valve for the government as for the private parties: if either side does not like the project at the time of ultimate decision on commitment of the bulk of the project funds, then no one actually spends the money.

In making the above observations, we do not mean to be critical of DOE or its staff. It is a large organization with many demands. It has good people. The same is true of Congress. We simply address the hard facts of the situation. If Congress puts DOE in the business of expediting and stimulating private sector supply development, then it must require of DOE that it work out ways to expedite rather than slow down specific private sector efforts to enhance energy supply. If the government wishes to arrange matters entirely to suit its own timetable -- and this applies to both Congress and DOE -- then it should be prepared to give up the object of stimulating the private sector and accept the responsibility of paying for projects entirely out of its own pocket. These words might be harsh were it not for the fact that the technology here discussed has been before the federal establishment for over a year and a half now, and there are private parties which are spending their money in an effort to move the project along in an expeditious manner.

Perhaps we should close by commenting briefly on more general topics.

We assume that there may be more than one project in the heavy oils/tar sands area which will yield a substantial public dividend on public expenditures. As noted at the outset, we are plunging more rapidly than expected into an area in which substantial innovation and capital expenditure will be needed. We do believe the synfuels legislation should provide for flexible funding authorities to support activity in this area.

However, on general technical and economic premises, we do not expect that federal involvement in the heavy oils/tar sands area will be required on the same scale as involvement in the coals conversion area, even though the total heavy oil/tar sands resource is quite large. As to the Hydrocabon Research Inc. heavy oil conversion technology, we believe at this point that once the technology is successfully demonstrated its use will spread without need for any further federal stimulus. More generally, as noted before, the processes required may often be more closely related to existing technologies than the coal conversion technologies. The risks may, on average, be somewhat less; the payouts quicker. One successful demonstration may stimulate much unassisted private sector activity.

But we do suggest very strongly that these same considerations suggest that the federal budgeting and funding processes recognize that projects in the heavy oils/tar sands area may often be able to proceed much more rapidly than the large, long range coal conversion projects; and of course much more rapidly than the nuclear fusion and similar very long range projects. Thus, the federal budgeting machinery should be geared to mesh with such shorter range timetables. Less money may be usefully laid out. Perhaps more of that advanced will be recouped. But when an outlay is needed, it should be made without extensive delays. The California Synfuels project is a case vividly in point.

MEMORANDUM BY HRI ON TECHNOLOGIES FOR DEALING WITH HEAVY OILS ALTERNATIVE TO HRI PROCESS

Evaluation of the California Synfuels proposal requires evaluation of the extent to which other processes may duplicate its results.

This question has been sharpened by the recent announcement of Ashland Oil Company to the effect that it has made a major advance in refining technology which will cut down on the amount of resids coming out of refineries, and produce more gasoline from an ordinary barrell of crude oil.

GENERAL SUMMARY

The major approaches to processing heavy crude oils or residual oil fractions are three: thermal cracking; hydroconversion; and catalytic cracking.

The two most widely accepted processes for handling such materials with significant sulfur and carbon residue are coking and hydrocracking.

Coking produces coke: a solid hydrocarbon. As the sulfur and metals contents of heavy oil feedstocks increases, the sulfur and metal contents of the cokes increase, and the cokes become less and less suitable for either electrodes or fuels.

Hydrocracking processes more effectively desulfurize the heavy oil feedstock, and convert it into more desirable gasoline and distillate fuels.

However, the current hydrocracking technology leaves as much as 20-40% of heavy residual oil fractions as an unconverted high sulfur residual oil fraction.

Catalytic cracking has a great range of uses in the petroleum industry. One of its limits has been related to the catalysts becoming inactive by "fouling", or becoming covered by, carbon and metals particles. The greater the carbon and metals content of the feedstock, the worse the problem. We have seen this as a major limiting factor in the use of the catalytic cracking technique in the heavy oils and tar sands area: by definition a portion of the hydrocarbon spectrum where carbon and metals contents are very high.

The HRI process combines elements of these approaches: using hydrogen under pressure in a way complementary to coke gasification, and using an inert carrier for handling coke particles instead of using a catalyst. The process tested out as making a total conversion of residual oil fractions and heavy oils as thick as and "dirty" as are experienced into boiler grade gas, naptha, and middle distillates; without any coke residue, and without significant atmospheric emissions. The combination is very fruitful.

The following table summarizes technical and economic advantages and disadvantages of available heavy oil processes.

MAJOR COMMERCIAL PROCESSES FOR HEAVY OIL UPGRADING

Process	Comments
A. Thermal Cracking	
1. Coking, delayed or fluid	Disposal of high sulfur coke a problem.
2. Flexicoking	Combines coking with gasification. Reduces but does not eliminate coke disposal problem. Produces low btu gas with limited economic uses.
B. Hydrocracking and hydrotreating	Reduces but does not eliminate high sulfur components.
1. Fixed bed	For low metals applications, excluding most heavy oils.
2. H-Oil	Only large scale commercial process. Uses ebulliated bed. Desulfurizes. Does not convert all of residuum; high pressure hydrogen use expensive.
C. Fluid catalytic cracking	Susceptible to metals poisoning. Has been limited in feedstock applicability. Ashland process is an apparently significant extension of this process. But has not been shown to be usable on feedstocks with carbon residues above 10%. Catalyst involvement suggests reason: very high carbon and metals percentages foul catalysts.

Until the Ashland announcement HRI saw no process which would seem to be considered a close substitute for the process we have called "dynacracking." The Ashland process at first sounded as if it might be such a substitute. However, examination of the published reports on the Ashland process indicates to us that this is not the case.

The Ashland reduced crude conversion process reports show application to only "atmospheric resids", not the more dense and carbon-rich vacuum resids; and to materials with less than 10% carbon residues. There is no indication that the Ashland process has been applied directly to very dirty heavy oils, as distinguished from refinery resids. There is also no indication that the process can be applied at small scales for field upgrading of heavy oils and tar sands materials.

We do not wish to downgrade the Ashland process. We believe it promises to be a useful tool in making more gasoline out of the crudes generally available. Ashland's accomplishment demonstrates that one does not have to be Exxon to contribute to petroleum technology. It should reduce to some extent the problem of heavy build ups of residual oils on the West Coast.

Ashland's process might seem to take away from our own. But we think there actually is great scope for both processes.

Our process addresses a different range of the hydrocarbon spectrum than Ashland's. The feedstock we anticipate handling might be seen as the worst third or fourth of the refinery resid feedstock reported for the Ashland process, plus heavy oils direct at the refinery and in the field, plus tar sands materials in the field.

The Ashland process should be applauded. But, on the basis of information to date and general knowledge of hydrocarbon technologies, it should not be seen as a complete answer to the resid problem on the West Coast and in the nation, or as a means of direct upgrading of heavy oils and tar sands materials. The HRI process takes up, in a sense, where the Ashland process leaves off. Thus, both may be of great importance to the nation in the future.

STATEMENT OF
ROBERT B. RICHARDS
GENERAL MANAGER
ADVANCED REACTOR SYSTEMS DEPARTMENT
GENERAL ELECTRIC COMPANY

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
UNITED STATES SENATE
APRIL 1, 1980

REGARDING THE LIQUID METAL FAST BREEDER REACTOR

My name is Robert B. Richards. I am General Manager of General Electric's Advanced Reactor System Department (ARSD) which has the project responsibilities for General Electric's activities in developing the liquid metal fast breeder and specifically includes General Electric's activities related to the Clinch River Breeder Reactor Demonstration Program.

We welcome this opportunity to present our views on the National Breeder Reactor Program with special emphasis today on the Administration's proposed FY 1981 budget.

However, before going into my views on those specific subjects, I believe it is essential that I present to you General Electric's view of the overall problem confronting the nation's nuclear energy capabilities so that the breeder reactor issues can be examined more properly in the context of the entire nuclear energy problem.

The United States faces an ever-present threat of a major cutoff in its foreign oil supplies. The threat constitutes a real, clear and present national security danger that must always be recognized as we determine how to assure that the nation's near and long-term energy needs are met.

The seriousness of that national security danger, combined with the damaging economic consequences of our excessive reliance on imported oil, provide the basis for Secretary Duncan's Posture Statement that he presented a few weeks ago. He said "The Department of Energy sees its mission as assuring the nation's orderly transition from an economy dependent upon oil to an economy relying upon diversified energy sources". We agree with that clearly stated mission and believe it is also our national energy mission. We also believe it must be carried out in the orderly fashion Secretary Duncan calls for but as quickly as is possible in view of the seriousness of the ever-present threat to our nation's security and well-being.

Achieving that objective requires that we reduce our consumption of oil wherever that is possible. The trend toward reduced gasoline consumption in the increasing number of smaller automobiles is encouraging from that point of view. And the government's action in deregulating oil prices, in phasing out natural gas price controls, in limiting the use of oil and gas in new industrial and utility power plants, in automobile mileage standards, etc., are all actions that should help to curtail our oil consumption. But with all the efforts to reduce oil consumption we will still have to find ways to substitute the various other available energy sources (including coal and nuclear energy) for those uses where oil is not an essential requirement. At the same time we should emphasize development of the emerging new energy sources.

The point we want to establish at this Hearing is that nuclear energy must be considered an essential part of this nation's diversified energy supply capability if we are to break the economic and national security bind in which we now find ourselves. But the viability of this nation's nuclear energy capability and the retention of nuclear energy as an option in its diversified energy system is no longer assured.

Since the 1973-1974 Oil Embargo, forecasts of light water reactor capacity, which represents our only currently available reactor capability, for the year 2000 has steadily declined from an ERDA forecast in 1976 of 600 gigawatts to a DOE forecast in 1979 of 200 gigawatts. Frankly, as things are now going, it is even difficult to see the low end of that range by the year 2000.

The latest DOE estimate means that no reactor commitments will be made for delivery before the year 2000. There are now already 190 gigawatts of reactors operating, being built, or on order. We have difficulty seeing how this nation's nuclear energy capability can be preserved in the face of that outlook.

Indeed, it is difficult to see a reversal in that trend of declining nuclear capacity forecast unless strong federal and industry action is taken to overcome the concerns about nuclear energy and unless strong federal action is taken to overcome the maze of obstacles and uncertainties that now preclude utilities from ordering reactors in spite of the many inherent advantages that they offer to the consumer.

Obviously, if the light water reactor nuclear capability is not to be preserved as part of this nation's energy system, then there will be no need for a breeder at any time in the future. But we will also not have the ability to return to the nuclear option if events show that it is necessary.

We are convinced (despite the continued financial losses that we foresee in our own nuclear energy businesses) that the nation will at some point have to turn back to our light water reactor nuclear energy supplies as part of its diversified energy system. And it is in that context, that we believe it is important to carry on a strong national breeder reactor development program as an insurance policy for the nation's continued ability to satisfy its energy needs well into the next century. We are pleased that the National Academy of Science CONAES report came to the same conclusion. The NAS report said "the LMFBR has the best chance of providing insurance that a nuclear industry could in the long term meet any electrical demands that might eventuate".

Thus, we do not believe the Administration's FY 1981 request of $320 Million for the Liquid Metal Fast Breeder Reactor program provides an adequate insurance policy. Indeed, the proposed $320 Million for the LMFBR budget is worth about $206 Million in 1976 dollars. At that time the LMFBR budget was $505 Million. Only $107 Million of the $505 Million was budgeted for Clinch River.

In prior years, the DOE support of technology development for LMFBRs has been at levels that provided confidence that a sound base for eventual breeder deployment could be established. The proposed FY 1981 LMFBR budget will no longer provide such confidence. The proposed reduced levels, in our judgment, will lead to the phase-out of the breeder program.

The Clinch River Project, as usual, is proposed for termination. The Conceptual Design Study (CDS) previously proposed last year at $55 Million has been reduced to $7.5 Million with the plan to put it on the "shelf" when finished in 1981. The LMFBR sodium test facilities (ETEC) are budgeted for a $5.0 Million reduction. Some safety related programs at Idaho will be cut in half and some facilities shut down. Fuel Cycle R & D will be reduced by a factor of four. The construction line item for reprocessing demonstration at ORNL ($6.4 Million) has been eliminated. During 1979 GE started deactivation of its Advanced Fuel Laboratory at Vallecitos. This was made necessary by the withdrawal of DOE support for plutonium processing activities.

The FFTF test reactor program is budgeted for continuation but it is difficult to see how operation can continue very long in the absence of a clear technological mission to support the eventual deployment of power producing machines. For those of us who have maintained that, short of a commercialization decision, breeder technology should be developed in such depth that a future deployment decision could be made with confidence, the proposed budget cannot provide the "insurance policy" we believe to be absolutely essential.

I would like now to turn more specifically to the Clinch River Breeder Reactor Demonstration. As I mentioned earlier, Clinch River is again to be terminated in the President's FY 1981 Budget. For the past three years, through the efforts of this Committee and other supporters in Congress, that project has been continued. I would like to give you my frank views of that project, recognizing especially the damaging confrontation that has developed, because of the efforts to terminate it, between the Administration and the Congress, industry and other groups.

I have been associated with the Clinch River Project since 1974. I believe the objectives for starting the project were sound. It was needed as a focus for developing breeder component technology; it provided a way of experimentally evaluating the technology of those components; it provided the systems tests that are essential before any new technology can be considered to be understood well enough to commit to larger, more costly, more nearly commercial prototypes; it was to be done at a size that was large enough in power level to be representative of full scale technology but at lower cost and, it had been expected, in a shorter time.

I still believe those objectives are correct and that significant progress has been made in the project to meet those objectives. I believe the Clinch River Breeder Reactor Demonstration can still meet those objectives, especially considering the great effort and cost that has already been devoted to it.

While forecasting the future can be a dangerous and uncertain exercise, it is our considered judgment that prudent planning should assume an increase in LWR application and provide a technology base for breeder deployment sometime in the 2000-2020 time frame. To provide a balanced industrial capability that would provide the utility industry with confidence in the technology, the Clinch River Project should be completed and operated for at least 5-10 years. The first of 2-3 1000 MWe prototype breeders should be brought into operation during the 90s and the remainder shortly after the turn of the century. A good technological base would then be available if needed by the year 2010. It will be essential that appropriate base development and fuel cycle support be conducted during this period of time. We believe such a program will be an excellent investment to provide a potential for electrical energy generation for several hundred years.

When the President first proposed terminating the Clinch River Project, in 1977, the major criticism concerned the problem of "proliferation". We are pleased to observe that while the problem has not gone away, present perceptions and understanding of the problem appear to be better balanced and more realistic. A recent DOE report of the Nonproliferation Alternative Systems Assessment Program (NASAP) issued in December 1979 quotes as follows: "All nuclear fuel cycles would entail some proliferation risks; there is no technical 'fix' "; and "the more promising resource extensions options are light-water reactor improvements (including reduced enrichment tails assay) and continuing development of the plutonium fueled breeder reactors".

There appears to be an emerging perception that control of proliferation will be an international cooperative effort involving the institutions developing and deploying nuclear reactors - including breeders. The recent International Fuel Cycle Evaluation (INFCE) has provided a clear demonstration that international cooperation is the only way to deal with proliferation effectively. For the U.S. to continue to control the proliferation issue in its own best interests, we must have the capability to interact as a full technological partner in the international arena. The proposed FY 1981 budget, we believe, gives a clear signal to our international partners that we can no longer "bring anything to the table", and that our influence on proliferation issues will diminish. We do not believe this to be in our best national interests or the world's at this time.

Later, the criticism was that the Clinch River design did not include our latest knowledge and technology, that it was obsolete, that a more advanced and better reactor could be built. In some respects, the Clinch River design calls for more advanced performance than we would now expect in a new design. Yes, there are changes we would undoubtedly make if we were to start over. But the basic objectives that were set when the project started and that I believe are still valid can still be met by Clinch River.

Another criticism has been that we could move faster and at lower overall cost if we dropped Clinch River and went instead to a larger (higher power) reactor that was more like the commercial prototypes. Obviously, there is no assurance that such a reactor will cost less than Clinch River. And I am one of those who believes that it is desirable to go through this lower power step before risking the higher investment associated with the several larger prototype reactors that would later be required to establish a true national breeder reactor capability if and when it is determined that we do indeed need such a capability. Obviously, this is an area in which honest differences can exist.

But it should also be recognized that even the Conceptual Design Study to examine such a larger reactor concept as a demonstration is reduced from $55 Million proposed last year to only $7.5 Million. So that design study is essentially eliminated in this budget. Therefore, there is grave danger that no significant system focus will exist any longer to serve as the basis for even a sound component and system technology development program.

The latest argument against continuing Clinch River and for justifying the substantial reduction in this Budget is that breeders will not be needed until well into the 21st century. That may very well be the case; noneof us knows. But I do not believe the insurance provided is adequate even in that case.

It is mainly because so many of us in the nuclear industry, in the utilities, and obviously here in the Congress, feel that the U.S. must have a strong breeder insurance policy that we are reluctant to give up Clinch River without being assured that a strong alternative breeder development program will take its place and will be pursued to its completion.

The objective of the national breeder program should be to achieve a high state of readiness so that the breeder may be deployed when it is needed. Therefore, I recommend the following:

1. The Clinch River Project should be continued as an active project.

2. A FY 1981 LMFBR Budget of about $500 Million should be approved in addition to the Clinch River Budget to maintain program momentum and industry capability.

3. The Conceptual Design Study should be extended to include Project Definition so that a decision could be made in the 1981-1983 period to proceed with a construction project.

In conclusion, I want to emphasize General Electric's concern with the difficulty of maintaining the United States' light water reactor capability in the face of the existing de facto moratorium. Solving that problem to assure that nuclear energy is preserved as part of this nation's diversified energy supply system should receive high priority attention and urgent action. There is real concern that the breeder controversy is diverting attention from the Government leadership and action needed to preserve the light water nuclear energy option. We won't need breeders if we disband our nuclear capability. We must not delay in setting up a sound, clear and assured basis for retaining this nation's nuclear capability. Therefore, we hope the differing views on the breeder can be quickly reconciled and firm decisions made so that breeder nuclear energy problems can be resolved.

RICHARD B. RICHARDS, GENERAL MANAGER, ADVANCED REACTOR SYSTEMS DEPARTMENT, GENERAL ELECTRIC CO.

We are pleased to present our views on the National High Temperature Gas Reactor Program, with special emphasis on the future potential of this concept to provide a source of high temperature process heat.

In past occasions when we have discussed advanced nuclear energy matters with you, we have advocated a strong liquid metal fast breeder reactor development program, including specifically the continuation of the Clinch River Project and the Conceptual Design Study. We have submitted separate written testimony to you on these matters.

This is the first year General Electric has approached the Congress in support of the HTGR development program. However, we have had a program of study underway in our Company on this technology for several years.

In prior years, the DOE support of technology development for the HTGR has been at modest levels aimed at providing confidence that a sound base for eventual HTGR application could be established.

It was appropriate that this be the case, given that the country's nuclear priorities lay with the LWRs followed by the LMFBR. However, the fact that the HTGR offers the promise to contribute to the resolution of some areas of our energy shortfall that cannot be served by the LWRs and the LMFBR has been recognized as good reason to continue such program support.

Clearly the Administration's proposed FY 1981 HTGR budget will no longer provide such confidence and will inevitably lead to the denial of the potential benefits which this nuclear system can offer.

The HTGR offers unique possibilities for the development of sufficiently high working temperatures to derive replacement portable fuels from coal, tar sands and oil shale, the production of process steam, electricity, hydrogen and synthesis gas. Even if only as an insurance policy against the day when we would need this energy, it would seem very prudent to carry on this activity for national strategic planning purposes. Experience shows that it takes decades to bring a new energy technology into full scale deployment. It took 40 years from the discovery of nuclear fission to the point where we produced 13% of our nation's electricity by this means. Extricating ourselves from excessive reliance on imported oil cannot be viewed as an alternative to be implemented overnight.

Of the four lead projects or programs outlined by the Gas Cooled Reactor Associates today, General Electric has a particular interest in the multi-purpose or "Multi-plex" energy application for the HTGR, whereby the reactor heat can be used for mid-range and peaking electricity generation and off-site for dispersed electricity and cogeneration applications. In this application the heat from the Multiplex HTGR is used to convert methane to a mixture of stable gases that can be piped at room temperature to multiple points of use. This is often called the thermochemical pipeline, or TCP. The thermal energy is regenerated at the users' sites where heat is extracted and the discharged methane is returned to the HTR for recycle. Applied in this fashion, such a plant can have an overall thermal efficiency, at the point of use, of greater than 80%, compared to the 30-40% efficiency of today's electric generating facilities.

The HTGR is well beyond the proof of concept stage. In the U.S. the prismatic core is operational in the Ft. St. Vrain electricity generating plant. The circulating fuel or pebble bed reactor has been demonstrated in Germany. Reactor outlet temperatures necessary to efficiently power the thermochemical pipeline have been achieved.

The Federal Republic of Germany's HTGR program involves a 15 MWe plant started in 1967 and a 300 MWe plant scheduled for operation in 1983. In addition, the FRG program involves extensive development of the ceramic nuclear fuel. This wealth of experience can contribute greatly to an efficient and productive U.S. program.

The remaining developmental efforts necessary to bring this promising technology to the point of being ready for use are primarily in the areas of materials development maintainability, reliability, constructability along with establishing a market focus and timing. As with most energy options the system's economics resulting from these developments will be a key determinate to system acceptance and to its value in enhancing the nation's energy security.

Similar gas cooled reactor programs, including process heat application, are underway in West Germany, Switzerland and Japan. DOE has initiated an "Implementation Agreement" with the FRG and Switzerland that establishes a structure for international cooperation on HTGR development.

Specifically, we endorse the recommendations that FY-81 funding include:

- A program to define a future system design, selected through an ongoing evaluation process involving DOE, GCRA, Oak Ridge National Laboratory, General Atomics and General Electric.

- continuation of DOE's international cooperative agreement with W. Germany, and initiation of similar activities with Japan. Such exchanges can amplify the investment applied by DOE.
- application engineering necessary for the integration of HTGR nuclear technology with the synfuels/process heat technology, and
- the continued development of the structural materials required for the key heat transfer and process piping components for this energy concept.

The applications and desirable features of this Multiplex HTGR system driving the thermochemical heat pipe are several:

- o With the exception of the price paid for piping and pumping there is no restriction on the distance the HTGR can be located from the users' sites, up to a few hundred miles.
- o No air pollutants are discharged from the HTGR facility or the users' sites;
- o The stable pipe line gas can be produced at an optimum rate, stored if necessary and used upon demand. This facilitiates a high utilization factor for the HTGR and low operating costs;

- The users can produce process heat at various temperatures, electricity or a combination of electricity and process heat;

and

- No critical energy resources are consumed.

The intrinsic storage capacity of the TCP would make nuclear-derived peaking and mid-range electricity generation practical, which would remove some of the obstacles to eliminating oil and gas consumption in the production of electricity.

In conclusion, let me summarize the foregoing key points and make some recommendations for the FY 1981 budget.

- The proposed FY 1981 budget will phase out the national HTGR program.
- We conclude that such a phase-out - at a time when excellent progress is being made in establishing a sound technological base - would foreclose the potential benefits to be derived from a new high temperature heat source.
- We believe that the FY 81 budget level of $55 Million proposed by GCRA would maintain the momentum of the

program and would afford the specific opportunity to bring closer the benefits of the process heat Multiplex concept. Industrial participation would thereby be encouraged.

In addition to the development of the HTGR, elements of the fuel cycle should be addressed. An effective program can be carried out in conjunction with on-going foreign developments with a restoration of $5.0 Million in the consolidated fuel cycle program that had been zeroed in the current FY 81 budget.

Last month, representatives of the Department of Energy testified before the Committee on Science and Technology, and I quote, "Although high temperature industrial process heat applications for this reactor have interesting potential, industry has not yet indicated a readiness to pursue such applications". We believe that the interest of the user and supplier industries will increase as the proposed development program demonstrates the potential benefits of the concept.

Thank you for the opportunity to discuss this vital matter with you.

TESTIMONY TO
THE SENATE COMMITTEE
ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

APRIL 1, 1980

BY

DAVID F. HANSEN
PRESIDENT AND CHIEF EXECUTIVE OFFICER
MEMPHIS LIGHT, GAS AND WATER DIVISION
220 SOUTH MAIN STREET
MEMPHIS, TENNESSEE 38101

It is a great pleasure to appear before you today representing the Memphis Light, Gas and Water Division. We are very pleased that the Department of Energy has agreed to build the first coal based synfuels plant using new American technology in partnership with us. This first plant is distinctly different from other synfuels projects under consideration. My purpose today is to tell you why the Memphis plant is different and why its success will have such a great impact on the new energy systems that we must develop.

My name is David F. Hansen, President and Chief Executive Officer of the Memphis Light, Gas and Water Division (MLGW). MLGW is a municipal utility serving 302,048 electric, 227,106 gas and 193,040 water accounts in the greater Memphis area. The utility is exceptionally strong financially with over $552,854,467 in assets at original cost and $148,858,339 in debt liability. The Division operates, maintains and does a majority of its own construction projects with 2,930 employees possessing diverse management, technical and craft skills. The Division has been an industry leader over the years in technological innovation.

The Memphis plant will take 3,150 tons of Eastern bituminous coal per day and produce 50 billion BTU's of clean medium BTU industrial gas.

The cost of the product, escalated for inflation, is projected at $5.37 per million BTU's in 1986. This price includes capitalization of a 20-month operational shakedown period and will permit repayment of all investment moneys by MLGW and the DOE. Number 2 fuel oil is selling today in Memphis, Tennessee, for $6.36 per million BTU's.

The plant will utilize the Institute of Gas Technology's U-gas gasifier. This is a new fluidized bed unit that is 70% thermally efficient in converting coal to gas as compared to 55% thermal efficiency for the conventional Lurgi process. The pilot plant performance at IGT in Chicago was excellent. Foster-Wheeler Corporation of Livingston, New Jersey is the architectural engineering contractor.

The Memphis project is unique, when compared to other coal conversion plants, because the plant will be built in a major urban center. The plant will work in parallel with the existing in-place Memphis natural gas system. A partial methanization train will take up to 30% of the coal gas plant product and convert it from 300 BTU's per cubic foot to 1,000 BTU's per cubic foot natural gas equivalent quality. This partial methanization train will be used to balance out the plant load factor and also to generate a credit into the natural gas system. This credit can then be withdrawn from the natural gas system when the plant capacity is not able to meet industrial gas demand or the industrial gas plant is off the line for maintenance or repair. The credit in the natural gas system will be stored in an underground gas field. When natural gas from the credit storage is fed back into the industrial gas system, it will be reduced from 1,000 BTU's per cubic foot to 300 BTU's per cubic foot by mixing with air.

With this marketing system, Memphis will be able to achieve high load factor from the industrial gas plant 24 hours per day. The natural gas credit system will also provide 100% supply backup to the industrial gas plant. Memphis industrial customers will not have to provide supplemental coal or oil fired energy standby as is currently required because of natural gas supply shortages. Two illustrations are included in this presentation to show how the Memphis marketing system works.

Two additional benefits will accrue to Memphis by use of this marketing system. First, because industrial customers will not have to provide their own coal or oil fired energy systems for either full time or standby operations, the ambient air quality will be significantly improved. The Memphis gasification process more efficiently removes pollutants and particulates than is reasonably practical when utilizing small individual coal and oil fired boiler plants. Second, 300 BTU industrial gas will cost only two-thirds as much to produce as 1,000 BTU's natural gas equivalent product.

Another tremendous benefit of a Memphis type plant is the fact it is being built at a major urban center. The investment, besides replacing imported oil, also provides jobs and opportunity in an existing metropolitan area. In other words, two major Federal objectives are served with a single project.

In Memphis, we currently have the government services, housing, schools, recreational areas, transportation facilities, professional and vocational skills, support organizations and all the things that are necessary to efficiently support a major energy conversion facility. The Memphis Coal Gasification Plant will provide jobs, attract additional industrial and commercial investment, maintain and improve the area's tax base and, in general, will provide opportunity and improve quality of life for citizens in the Memphis area.

Strangely enough, the Memphis project is the first to couple investment and new energy systems with improvement in urban area economy. The theoretical modeling of coal based synfuels has primarily considered mine mouth operations only. There has not been an appreciation that a coal conversion plant could operate in parallel with an in-place natural gas system and produce a better economic result than is possible with a remote plant site.

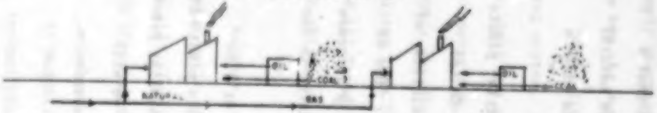
Using the Memphis marketing system, SRI estimated similar plants could be successfully located in up to 79 urban centers in the United States. The SRI marketing study did not even consider the possibility of partial methanization, such as we will be utilizing in Memphis. Use of partial methanization and the credit system should substantially increase the number of urban center plants that can be successfully located in the United States over the 79 identified in the study.

It is a real pleasure to describe the plant that we will be building in Memphis. Our objective is to build and operate this plant within budget. When that is accomplished, the investment funds for similar plants will become readily available at reasonable capital costs and we will finally be on our way towards achieving reasonable energy independence.

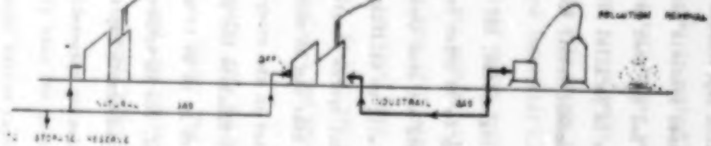
ILLUSTRATION NO. 1

HOW THE ENERGY SYSTEM WORKS

1) PRESENT CONVENTIONAL SYSTEM


OIL
COAL
OIL
COAL
NATURAL
GAS

2) THE MEMPHIS SYSTEM--INDUSTRIAL GAS PLANT ON


POLLUTION REMOVAL
OFF
COAL
NATURAL
GAS
INDUSTRIAL
GAS
TO STORAGE RESERVE

3) THE MEMPHIS SYSTEM--INDUSTRIAL GAS PLANT OFF

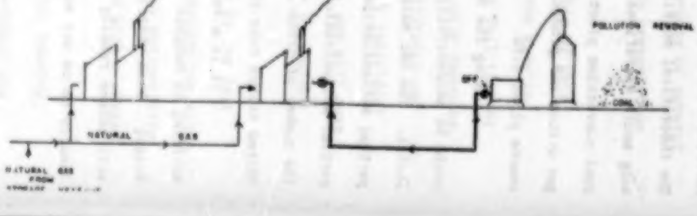
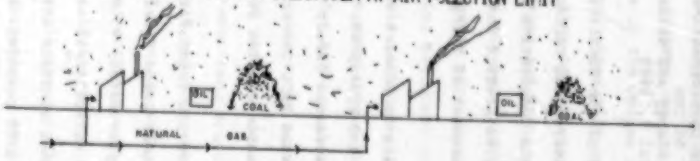

POLLUTION REMOVAL
OFF
COAL
NATURAL
GAS
NATURAL GAS FROM STORAGE RESERVE

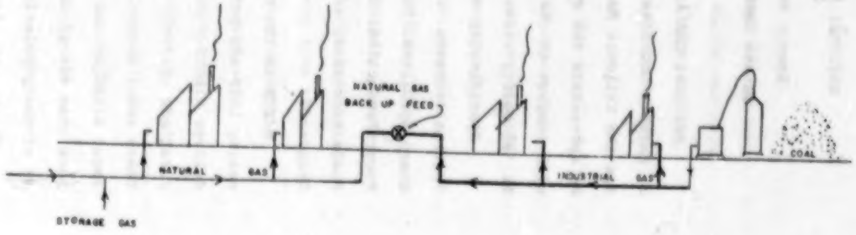
ILLUSTRATION NO. 2

ECONOMICALLY FEASIBLE INDUSTRIAL GROWTH AGAIN POSSIBLE IN URBAN AIR QUALITY ATTAINMENT ZONES

1) PRESENT SYSTEM--URBAN AREA AT AIR POLLUTION LIMIT


OIL
COAL
NATURAL
GAS
OIL
COAL

2) THE MEMPHIS SYSTEM--OIL & COAL DISPLACEMENT


NATURAL GAS
BACK UP FEED
NATURAL
GAS
INDUSTRIAL
GAS
COAL
STORAGE GAS

STATEMENT OF
NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION
On FY '81 DOE Authorizations
before the
Energy Research and Development Subcommittee
of the
Senate Committee on Energy and Natural Resources
April 7, 1980

Mr. Chairman and Members of the Committee: My name is Lowell J. Endahl, Coordinator of Research and Technological Development for the National Rural Electric Cooperative Association (NRECA). We appreciate the opportunity to present the NRECA membership views with respect to the U.S. Department of Energy Authorizations for FY '81 energy research.

Specifically we would like to comment on: Electric Energy Systems research, Geothermal and Hydropower funding, Nuclear Energy programs, Fuel Cell Research, Direct Burning of Peat for Power Production, Solar and Wind R&D, Commercialization of Synthetic Fuels Processes, and Conservation and the Building Energy Performance Standards.

NRECA is the national service organization which represents nearly 1000 non-profit, consumer-owned rural electric systems which deliver electric power to approximately 25 million people in the rural and sparsely populated agricultural areas of 46 states. These small cooperatively-owned electric utilities are located in about 2,600 of the nation's 3100 counties, and they own and operate more than 40% of the distribution line in the nation to serve about 9% of the population.

These rural electric cooperatives at their annual meeting (March 3-6), attended by more than 10,000 people (mostly directors and managers of rural electric systems) adopted a series of resolutions on issues of concern, some of which pertain to energy research. The pertinent resolutions are attached.

Electric Energy Systems Research

Since rural electric systems own and operate over 40% of the electric distribution line in the nation and serve in the sparsely settled areas of the country where wind and solar energy systems are likely to be popular, they have a special interest in the work of the Electric Energy Systems and Storage research.

A host of new problems are beginning to surface for rural electric systems as small power producers and cogenerators, with all types of power generating equipment (i.e. wind, solar, biomass and hydro) seek to sell their surplus energy to the cooperative utility. All utilities are required to purchase this energy from the qualifying producer under PURPA sections 201 and 210. While rural electric systems are willing to purchase this self-generated energy of their members, the problems connected with the integration of small quantities and intermittent sources of energy into the utility grid can be difficult and uneconomical. Such problems involve energy storage, and also the technical electrical and safety problems of producing acceptable utility quality power. We are pleased that DOE has instituted a research project to study the interface problems of small power producers, but we believe that this work needs to be expanded. A major research effort is needed to develop low-cost integration and storage equipment in order that solar, wind, and other supplemental energy sources can produce utility quality power economically.

We respectfully request that an additional $4 million be added to the EES budget in order that this study can be expedited and the necessary research completed, and information made available promptly. We also request that the Storage Battery Electric Energy Demonstration (SBEED) be stepped up and an additional $3 million be allotted to this program which is conducted in cooperation with Wolverine and Northern Michigan Electric Cooperatives.

Rural electric systems also strongly support the research work underway on Extra High Voltage (EHV) Transmission and studies relating to electric field effects (resolution attached). Recent experiences in acquiring right of way and constructing EHV lines have revealed serious misconceptions, mystique, and fearfulness on the part of the general public as to the electric field effects on vegetation, animals, and even people living near EHV lines. Results of the research work underway are urgently needed.

Geothermal and Hydropower Funding

The electric cooperatives, which serve in approximately 75% of the land area of the country, are ideally located to take advantage of the geothermal and hydro resources throughout the country. Raft River Electric Cooperative in Idaho has been actively involved in the development of the binary cycle geothermal system utilizing the moderate temperature geothermal resources. There are vast quantities of this moderate temperature (about 300°F) resource throughout the nation, and we urge that the system for utilizing this resource economically be developed as quickly as possible, and that research for that purpose be supported to its practical maximum.

Hydropower is also of great interest to rural electric systems, with many systems actively studying the possibility of utilizing small-scale hydro resources in their areas. The Rural Electrification Administration is also encouraging the cooperatives to investigate possible hydro sites which might be financed through that agency. In view of this increased activity, we believe that the demand for assistance through the DOE Feasibility Studies Loan Program will increase dramatically. In addition, in order that small scale hydro can be given an opportunity to make a worthwhile near term contribution to the energy supply, we believe that the Small Scale Hydroelectric Development should also be increased. We would like to see the size definition of small-scale hydro revised upward from "less than 15MW" to "less than 30 MW" to increase the number of qualifying sites and increase the power potential and economic feasibility.

In view of stepped up rural electric interest in small scale hydro development, we respectfully request that FY '81 authorization for Small Scale Hydroelectric Development be increased from $8.2 million to $12 million and the Feasibility Studies Loan Program be increased from $10 million to $12 million.

Nuclear Energy

We were dismayed to review the proposed Nuclear Energy authorization budget and find that the Breeder Reactor Systems budget had been cut in half (from $761.8 to $384.0). It is inconceivable to us that, at a time when this nation is struggling to reduce oil imports, R&D on one of the major technologies that could help us achieve future energy independence is being curtailed. In time of war, a nation would not destroy its best weapon. In the energy battle, the breeder reactor could be our biggest and best weapon.

Consumer-owned rural electric cooperatives have gone on record repeatedly urging the rapid completion and commercialization of the Liquid Metal Fast Breeder Reactor at Clinch River. They reaffirmed that position at their business session of the annual meeting on March 6, 1980, asking for an "aggressive program for development and commercialization of the breeder reactor to insure sufficient fissionable resources for an independent energy future for America in the twenty-first century." We strongly urge that the Breeder Reactor Systems budget be reinstated to the level of last year.

Nuclear Information Program

Much of the confusion and indecision on national energy policy, particularly with respect to nuclear power, seems to have been generated by misinformation. While there are good sources for reliable information, the public is not always willing to accept or recognize those sources. The media has a tendency to stimulate debate and use opposing views to create news stories. Unfortunately such reporting often adds to the confusion, and creates new uncertainties about "who is right." NRECA member systems, conscious of this problem, adopted a resolution calling for a government nuclear information program that would serve as an accurate and creditable source of information on nuclear energy, with the further responsibility of challenging misinformation. We urge that Congress institute and fund such a program similar to the Conservation Information Program.

The resolution on Nuclear Information is as follows:

> The American public is concerned and confused by the wide variety of opinions and alleged "facts" presented on nuclear power from hundreds of sources. There is no single recognized creditable source of such information which members of the public and the Congress can use with confidence, or which will be universally accepted. Much misinformation about nuclear power has been

disseminated without challenge. The result could be disastrous to our nation's National Energy Policy.

Rural Electric Cooperatives believe that the American public should be confronted with the true facts about nuclear power and we believe that it is the responsibility of the Federal government to see that proper and accurate information based on scientific research and analysis is widely disseminated.

We propose that Congress take immediate steps to formulate a program and budget (similar to the Conservation and Solar Information Program) to properly inform the public about nuclear power and challenge misinformation.

Fuel Cell Research

Rural electric systems have again expressed, through the attached resolution, their interest in the rapid commercialization of the fuel cell for electric power generation. They see significant potential for fuel cell power plants in rural areas, and they are actively participating in the industry-wide Fuel Cell Users Group which is dedicated to the commercial application of phosphoric acid fuel cell technology. The next step in establishing commercial viability of the multi-megawatt fuel cell involves broad exposure to the market environment. But the risk of proceeding as a strictly private investment has become unacceptably high, due to the economic climate and other factors beyond utility control.

The fuel cell technology has been developed to the point that it shows promise of economic benefits for the consumer, improved service availability, conservation of fuel resources, and a cleaner environment. It is, therefore, both essential and proper that the Federal government assume a significant portion of the financial burden of development and commercialization.

Rural electric systems also have a great interest in the 40 kW fuel cell program which involves the field testing of a number of the units under a variety of conditions. In particular rural electric systems provide an ideal vehicle for implementing a program to use these small fuel cell units using methane as a fuel. Special attention should be given and funding provided to test at least four such units in applications involving agricultural production of methane (swine, cattle feeding and dairy operations) and a like number utilizing methane from coal seams to generate utility quality power. Such applications are completely compatible with the current thrust to encourage small diverse power production.

We respectfully request that the 40 kW fuel cell program (about $10-million) be reinstated, and that an additional $3 million be earmarked for testing of the units in a diversified mode using methane as the fuel.

Peat for Power Production

The use of peat as a fuel for electric power production has never been attempted in the United States in spite of the fact that there is more peat available than any other fossil fuel with the exception of coal. There are vast resources of peat in areas served by rural electric systems. Peat has been used as a direct burning fuel for power generation in foreign countries. However, harvesting techniques and the materials handling problems are likely to be quite different in the United States. Rural electric systems, particularly in North Carolina, are eager to assist in the development of a first-of-a-kind large scale demonstration facility for the direct burning of peat for power generation. (see attached resolution)

Most of the $13 million proposed for peat R&D in the FY '81 budget is earmarked for peat gasification ($9.1-million) with about $8-million flowing to the Institute of Gas Technology. We believe that the direct burning of peat shows even greater immediate promise for utilizing these vast resources, and we respectfully request that the FY '81 budget request be increased and $4-million earmarked for the initial phase, including a feasibility study, for a large scale direct combustion of peat power plant.

Wind and Solar R&D

Rural electric systems support the effort to develop supplemental/alternative energy sources and appropriate scale technology. (see attached resolution) Many rural electric systems have initiated solar and wind energy demonstrations on their own, and a few are participants in DOE sponsored R&D projects. These non-profit electric cooperatives, because of their organizational structure and the areas that they serve (open agricultural areas beyond the natural gas lines), offer unique opportunities to implement such technologies.

We support the funding of the proposed solar technology budget, except that we believe that additional funding could be used effectively in the wind energy program, specifically to evaluate the wind resources in this country. There is need for wind monitoring stations at some 1000 locations throughout the country to specifically evaluate solar and wind resources for extended periods of time before energy facilities are installed. A program such as that called for in H.R. 5892--Wind Energy Systems Research, Development and Demonstration Act of 1979, would be desirable. We commend the Congress and DOE for funding and implementing such projects as the 2 Mw Wind System at Boone, N.C. and the Wind Power

Development at Medicine Bow, Wyoming. (see attached resolution)

While we support full funding for the proposed solar technology budget, we believe that even greater effort could be made by DOE Solar to capitalize on the opportunities that exist for program implementation and for technology commercialization by working closely with consumer-owned, non-profit rural electric cooperatives throughout the country, and by demonstrating the technology in rural areas of the country where these technologies are most feasible. We believe that if wind and solar energy are ever to make a noticeable contribution to our nation's energy supplies, the thrust for that effort must come in the areas where the resource is greatest-- in areas generally served by rural electric cooperatives. Looking ahead to the day when these technologies are developed and competitive, and when they find their niche in the marketing process, it makes sense that the users of the technology (rural electric cooperatives) should have had experience as a result of the demonstration program. We hope that Congress and DOE will make it possible for rural electric systems to gain that experience by involving them in an increasing number of demonstration programs.

Special problems exist in connection with the integration of these intermittent sources of energy into the utility grid. Such problems involve energy storage, and also the technical electrical and safety problems involving the sale of utility quality power by small producers to the utility. A major research effort is needed to develop low-cost integration equipment in order that solar and wind power of utility quality can be economically produced and readily accepted by the utility. DOE Solar Technology staff should recognize this problem, but the responsibility for research must necessarily be that of the Electric Energy Systems and Storage.

Synthetic Fuels Program

Rural electric cooperatives support a strong program to develop and commercialize acceptable processes to produce synthetic fuels from existing abundant fossil fuels and renewable energy resources (membership resolution attached). Concern is expressed over energy policies that encourage increased oil imports and the disastrous effect that such policies could have on the nation's economy and living standards. Rural electric systems support a major research, development and demonstration program that can begin to reduce the stranglehold that oil-producing nations now have over us.

We note, however, that P.L. 96-126 (Department of the Interior and Related Agencies Appropriations for Fiscal Year 1980), Title II Department of Energy, Alternative Fuels Production, appears to limit the utilization of our abundant resources to those processes which produce only solid, liquid and gaseous fuels. It does not recognize that often the most efficient and effective use of listed resources is in the production of electric power. The current interpretation of P.L. 96-126 in the recent solicitations for alternative fuels production specifically rules out direct combustion applications which might be the best way to use the resources. For example, it is conceivable that the best application of unconventional gas is direct use in production of small scale electric power. In many cases the gas produced from unconventional gas wells is not of pipeline quality, or is not available in sufficient quantity to warrant construction of pipelines. But this otherwise unusable fuel can be burned at the well site to produce electric power on a small scale.

In addition it is likely that in certain locations the most effective and efficient way to use the peat resource is by direct combustion to produce electric power. However, much research and development is needed to resolve the materials handling problems and those associated with boiler design before peat can be utilized to its maximum. We respectfully request that the Congress not limit the opportunities for maximum utilization of resources by ruling out direct combustion for production of electric power, except in the cases of coal and lignite where the technology is perfected.

Once again, we urge that DOE development and demonstration funds be made available for consumer, non-profit corporations that desire to participate in the development of the technology and resources.

One such organization is the Consumer Energy Corporation of Cameron, Missouri, which has submitted an unsolicited proposal to the Department of Energy for financial assistance to carry out certain tasks in the design stage of a project to construct two Combined Power Cycle Coal Gasification Energy Centers in rural Missouri. Consumer Energy Corporation has been supported through the costly feasibility studies without government help, by the enthusiasm and contribution of individuals and organizations throughout the state (including several electric cooperatives). Assistance is now needed to carry the project forward. We urge that $2 million be included in FY '81 budget for feasibility and engineering design studies for such not-for-profit energy corporations.

Conservation and Building Standards

Rural electric cooperatives are deeply involved in conservation efforts to help their member-consumers in the wise and efficient use of energy. A major concern and effort involves the weatherization and retrofitting of existing homes to conserve energy for space conditioning. Rural electric systems for many years urged higher standards for insulation and energy efficiency in buildings, as well as better weatherization and insulation techniques and materials. (see attached resolution)

With these views, and concerns for consumers' heating and cooling bills, rural electric systems were greatly disappointed in the Building Energy Performance Standards recently proposed by DOE. The proposed standards have the effect of encouraging the use of imported fuels--in direct contradiction to our national energy policy. It permits builders to design less efficient buildings if oil or gas is to be used as a fuel, (see attached resolution) and the resulting poor building efficiencies would negate for all time the opportunity to retrofit residences for solar energy. We wish to call this to your attention for two reasons: 1) Such a building energy standard cannot be in the national interest, and 2) DOE has wasted several millions of dollars in developing this proposed standard which we feel goes far beyond the intent of Congress in dictating fuel usage, and which will require millions more to implement. We have suggested a far simpler standard.

We realize that the Committee and Congress are trying to hold down excessive expenditures in an attempt to produce a balanced budget. We commend you for that. In this statement we have suggested several relatively small increases in the DOE FY '81 budget, and we also suggest that funds to compensate for these increases might be found in the energy conservation budget. The Energy Information Campaign, for example, might be conducted at far less cost, by requesting the voluntary support of the media, and national, regional, state and local organizations. Conservation is in everyone's interest. Many organizations, like NRECA, already have membership communications and education networks in place that could not, and should not, be duplicated. In addition, it might not be necessary to continue to fund state energy offices where similar or duplicate facilities and services are available at land grant colleges. We urge that the extension unit of the Science and Education Administration of USDA and the land grant college information and educational offices be consulted on such a major energy information campaign.

We appreciate the opportunity to express these views for your consideration in developing the FY '81 DOE budget.

RESOLUTIONS ADOPTED AT THE
NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION
38TH ANNUAL MEETING--MARCH 3-6, 1980

SUBJECT: Federal Support for Fuel Cell Commercialization

Rural Electric cooperatives have great interest in the development of fuel cell power plants because of significant advantages not found in conventional generating equipment. These characteristics show promise of economic benefits for the consumer, improved service availability, conservation of fuel resources, and a cleaner environment.

Commercialization of fuel cell power generation is so near, yet so far from being achieved. The phosphoric acid fuel cell has been developed to the point of large-scale demonstration at the power plant level. But the continued commercial development of the fuel cell continues to need major Federal government financial support.

The next step in establishing commercial viability involves broad exposure in the market environment. The risk of proceeding as a strictly private investment has become unacceptably high, due to the economic climate and changing and unpredictable government involvement in utility decisions.

It is both essential and proper that the Federal government assume a significant portion of the financial burden. We urge the Department of Energy, with support from the Congress, to support a comprehensive integrated program with all segments of the utility industry to provide a basis for commercial fuel cell power plant development for electric utility servic

SUBJECT: Federal Support for Peat as Fuel for Power Generation

Rural electric cooperatives have great interest in the development of peat as a viable power plant fuel for use in the United States.

There is more peat available in this country than any other fossil fuel with the exception of coal. Current technology for utilizing peat as a direct buring fuel for power generation has been used in foreign countries but harvesting techniques and peat-fired power generation have not been proved in the United States. The first demonstration facility to hasten the development of this new fuel will be costly since it will be the first of a kind plant in the United States.

The risk associated with the development of these facilities utilizing private investment could result in significant delays in the utilization of this most valuable fuel. Therefore, it is both essential and proper that the Federal government assume a significant portion of the financial burden for a large scale demonstration facility.

We urge the Department of Energy with the support of Congress to cooperate with rural electric cooperatives and all other segments of the utility industry in the development and testing of a demonstration power facility utilizing peat as a boiler fuel.

SUBJECT: Reduced Dependence on Petroleum Through Research

Continuation of present energy policies that encourage increased oil imports will have a disastrous effect on this nation's economy and living standards. All indications are that imported oil prices will continue to rise.

We believe that this nation must act promptly and decisively to reduce dependence on imported oil; and a major part of that effort should involve an expanded research, development, and demonstration (RD&D) and commercialization program.

We believe that emphasis on the following programs is essential to ultimately achieve reduction of dependence on foreign oil:

1) Development and commercialization of acceptable processes to produce synthetic fuels from existing abundant fossil fuels and renewable energy resources;

2) Development and demonstration of electric power production emphasizing economically feasible supplemental/alternative energy resources and improved technology in coal utilization;

3) Establishment of policies to shift from an oil-based economy to an electric economy where abundant coal and nuclear resources can be fully utilized; and

4) Development and commercialization of conservation technologies, more efficient electric appliances and equipment (i.e., energy efficient heat pump water heaters), and electric vehicles which -- in many instances -- can replace gasoline-powered vehicles.

We welcome the new initiatives of REA in providing Loan Funds related to the supplemental energy field and encourage rural electric cooperatives to take full advantage of this opportunity, along with other available funding, to help bring emerging supplemental alternative energy technologies into the commercialization stage.

We respectfully urge the President and the Congress to act promptly to establish policies and to fund major RD&D and commercialization programs, as outlined, that can begin to reduce the stranglehold that oil-producing nations now have over us. We further urge that rural electric cooperatives, as consumer-owned organizations, be recognized as ideal utilities to implement demonstration and commercialization programs and that the Rural Electrification Administration be given the authority and the funding to carry out these programs with the assistance of NRECA.

SUBJECT: DOE Research on Alternate Energy Sources & Technology

A balanced program of energy research, development and demonstration is essential to the nation's energy future. In the interest of such balance, we support an increase in DOE efforts to develop alternate energy sources and appropriate scale technology. In particular we support continued efforts to develop:

(1) Solar energy systems including residential heating and cooling, wind energy, and solar thermal and photovoltaic generation of power;

(2) Geothermal power - particularly the co-op initiated Raft River geothermal project;

(3) Energy storage systems both for consumer and utility use;

(4) More efficient small and medium scale power generation systems which can utilize coal and/or waste products and which can be used in a co-generation mode, such as coal burning diesels and the stirling engine.

We also respectfully urge that the DOE give special attention and make arrangements to demonstrate these technologies in cooperation with consumer-owned electric cooperatives, which offer unique opportunities to implement such technologies on a broad scale for the benefit of consumers on a non-profit basis.

We further urge that in development and demonstration of each such technology, special recognition and attention be given to its impact on and compatibility with the electric system.

Rural electric systems desire to assist in maximizing the consumer benefits of such technology while at the same time minimizing possible detrimental effects on the power system.

SUBJECT: Government Support for a Revitalized Nuclear Program

The availability of adequate amounts of power and energy are vital to the future growth and security of our Nation as the leader of the Free World. As a direct result of uncertainty, indecision, and deliberate delay on the part of the Federal government, our Nation faces the spectre of power blackouts, declining productivity, spiraling inflation, and increasing inability to compete in the international marketplace, resulting in growing unemployment and potential civil unrest.

Any honest and realistic examination of the power outlook in America today clearly indicates that if the Nation is to deal effectively with these growing energy-related problems, nuclear power must play a significant role for the foreseeable future. There is no other way that the United States can realistically meet its most modest requirements for electricity without completing some 125 nuclear power plants now under construction and constructing additional units as the energy requirements of the Nation continues to increase.

The Department of Energy in its most conservative estimate states that nuclear power must increase from six quads in 1985 to 16 quads by the year 2000. Translated into requirements for installed nuclear capacity, this means that in 1985 there should be approximately 120,000 megawatts; similarly, by the year 2000 there would have to be available at least 330,000 megawatts of nuclear plants.

We recommend that the Federal government should set the policy and both the Administration and the Congress must provide leadership and support for an aggressive nuclear program. It is of vital importance that positive action be taken to:

1. Simplify and shorten the nuclear licensing procedures, encouraging the issuance of needed limited work authorizations, construction permits, and operating licenses on a timely basis. In concert with these actions, lifting of the moratorium on nuclear power plant licensing in general should be effectuated by the NRC without further delay, thereby mitigating the deepening dependence of our Nation on foreign oil purchased at ever-higher cost, fueling inflation and continuing to erode the living standards of Americans everywhere.

2. Provide for Federal government processing and storage of nuclear fuel in order that residual fissionable uranium and newly-generated fissionable material which -- through recovery and recycling -- can generate up to 50 percent more energy from the same fuel to provide the equivalent of over one-half of the Nation's proven oil reserves. Forthright action should be taken by the Federal government to construct and to place in operation a repository for permanent high-level waste disposal at the earliest possible time, as a part of a national nuclear waste disposal program developed in partnership with appropriate State governments.

3. Provide continuing leadership and encouragement to the nuclear industry to build upon the lessons learned from Three Mile Island, which has already led to improved safety in design, construction, and operation of nuclear power facilities.

4. To go forward with an aggressive program for development and commercialization of the breeder reactor to insure sufficient fissionable resources for an independent energy future for America in the twenty-first century.

SUBJECT: The Breeder Reactor and Nuclear Energy Research

We are deeply concerned by the Administration's de-emphasis of nuclear power as a viable power option of the future and the resulting neglect of research and development involving nuclear power in general and the breeder reactor in particular.

Arguments made against nuclear power on the grounds of safety including possible diversion of weapons grade plutonium and/or nuclear proliferation are grossly overstated and misunderstood. Nevertheless, in view of these expressed concerns and because of the urgent short-/and long-term needs of power which can be supplied only by full utilization of the nuclear power option, we respectfully urge that Federal research in the nuclear power field by increased and redirected to deal with the so-called proliferation problem as it relates to nuclear power by a refined and revised fuel cycle and continued development of the breeder reactor.

We further urge that decisions be made promptly, based on existing research information, to provide the technical basis upon which a viable nuclear technology, including the breeder option, can be implemented. Such decisions must address the need for insuring sufficient fissionable resources and enrichment capacity, providing development of fuel reprocessing facilities and a breeder fuel cycle, and a permanent disposal technology for high level wastes.

We commend those members of Congress who continue to aggressively support adequate, reliable power for the future, independent of foreign energy supplies. This must include the nuclear power option, and the breeder reactor. We also urge prompt consideration of the Clinch River Breeder Reactor Demonstration Project.

SUBJECT: Proposed Revision of Building Energy Standards

Rural electric cooperatives support the need for stringent standards for energy efficient buildings as mandated by Congress in the Energy Conservation Standards for New Buildings Act of 1976 (Title III, PL 94-385).

We feel, however, that the Department of Energy (DOE) has severely distorted the intent of the legislation in its proposed Building Energy Performance Standards (BEPS) by incorporating "weighting factors" and considerations other than efficiencies in new buildings.

Specifically, the proposed BEPS attempts to account in part for energy losses occurring at electric powerplants, oil refineries and gas-processing plants, and in part for the "social costs" of the use of various forms of energy. Weighting factors create a three-to-one preference against the use of electricity that will effectively dictate the use of oil or natural gas wherever there is a choice to be made.

Furthermore, under the proposed BEPS, building designers would be permitted to design a less efficient building if the fuel to be used is natural gas or oil; and we feel this is contrary to national energy policy and dilutes efforts to promote energy conservation.

A better approach, one that will implement the clear intent of Congress would be to base energy budgets on annual space heating and cooling loads, all expressed in BTU/ft.^{2} A single number should be provided, one not dependent on fuel and energy use but established at the maximum practicable level of insulation and glazing consistent with national energy policy and economic concerns. This will help assure that the building envelope is designed to attain maximum practicable efficiency throughout its useful life, and so also will encourage use of passive solar techniques, something which is not specifically encouraged through BEPS as now proposed.

This approach also will give complete freedom to owners, builders and designers in selecting the techniques to attain energy efficiency as well as the systems and energy sources which they prefer. The systems and equipment selected in single-family residences will be energy efficient by virtue of the minimum appliance efficiency standards being developed by DOE. This standard easily can be expanded to encompass the systems and equipment commonly found in commercial buildings.

SUBJECT: Insulation and Weatherization Research

Hundreds of thousands of American homes and commercial structures are being insulated and weatherized, many of them through programs sponsored by rural electric cooperatives. With such a large variety of insulation materials, application methods and installation techniques as is available, problems of moisture condensation, fire hazard, wood rotting, toxicity, paint blistering, etc. may occur.

We urge that the U.S. Department of Energy conduct a literature search and publish an abstract to provide a source of information to all energy suppliers and insulation installers which would result in the improvement of insulation products and installation procedures.

While some research is currently in progress, we recommend that an expanded research program be undertaken by DOE which would lead to improved insulation and weatherization standards, materials and installation methods, especially those employed for retrofitting existing structures including modular housing and mobile homes.

SUBJECT: Nuclear Waste Disposal

Radioactive waste management has been the subject of countless studies and reports. The overwhelming consensus of these studies is that radioactive waste can be handled and disposed of safely, with no serious public health and safety or environmental effects.

Many competent groups have determined that the technology and means are at hand to safely store and dispose of nuclear waste and nearly all of such waste is generated by the Federal government's weapons program.

We urge the Federal government in partnership with the States to immediately provide and implement an affirmative policy and program for the safe storage and disposal of nuclear waste.

SUBJECT: Extra High Voltage Transmission Line Research

The increased use of extra high voltage (EHV) overhead transmission lines for transmitting electric power by rural electric cooperatives is essential if we are to continue to provide the electric power needs of rural America. Recent experiences in acquiring right of way and constructing such EHV lines have revealed serious misconceptions, mystique, and fearfulness on the part of the general public as to the electric field effects on vegetation, animals, and even people living in close proximity to such EHV lines.

Although such concerns are not supported by scientific evidence, we have an urgent need to provide positive, scientifically demonstrated evidence that there are no significantly adverse effects upon vegetation, animals and people living in close proximity to such EHV lines. NRECA urges the Congress and the Department of Energy to adequately fund the electric fields research work being conducted by the DOE involving both alternating and direct current overhead EHV lines and disseminate such information to the public.

ENVIRONMENTAL POLICY CENTER STATEMENT CONCERNING THE FY 1981 DEPARTMENT OF ENERGY BUDGET FOR NUCLEAR PROGRAMS

On behalf of the Environmental Policy Center, I wish to thank the Committee for the opportunity to testify on two major aspects of the Department of Energy's budget for nuclear programs: the Administration's proposed cuts in the advanced reactor programs, and the Department's nuclear waste programs. We urge the Committee to support the President's cuts in the Liquid Metal Fast Breeder Reactor program($142.7 million), cancellation of the Clinch River Breeder Reactor, cuts in fuel cycle R&D($40.5 million), cuts in the High Temperature Gas Reactor($25 million), and the Gas Cooled Fast Breeder Reactor($26 million). These technologies will not materially add to the Nation's energy production capability until will into the next century, while diverting resources away from near-term development of other more cost-effective technologies.

The Department of Energy's NASAP study("Report of the Nonproliferation Alternative Systems Assessment Program", DOE/NE-0001, December 1979)found that reprocessing and breeder programs would not significantly aid the nuclear fuel supply/demand balance until 2010 or 2025, and then only if there were very high nuclear growth. If nuclear growth was low, approximately 255 GWe by the year 2000, nuclear development would "...not be constrained by uranium supply to any great extent." In either case, expected improvements, identified in the NASAP study, in uranium utilization(20% to 25% improvement by the year 2000) and in uranium enrichment(20% by the year 2000)could more than offset the 20% gain in nuclear fuel supply which could be expected from reprocessing.

The NASAP findings are rather conservative since they are based on high nuclear growth rates. NASAP used the Energy Information Agency 1978 Annual Report published in the summer of 1979. This data projected a median growth of nuclear capacity by the year 1995 of 208 GWe. However, the EIA subsequently revised its nuclear growth estimates downward in October 1979 by 15% to a median on 179 GWe. These revised estimates indicate that any anticipated benefits to nuclear fuel supply from breeder reactor and reprocessing programs will not materially affect the supply of nuclear for the U.S. until midway into the next century; a finding echoed by the NASAP report which stated that the improvements in uranium utilization and enrichment would preclude any significant supply/demand imbalances for nuclear fuel well into the 21st century even if nuclear growth were to reach the level originally projected in 1978 of a median of 325 GWe in 2000. I again urge the Committee to honor the President's recommendations to defer these advanced reactor programs.

In the area of nuclear waste management, the Environmental Policy Center is concerned over the lack of redirection of the DOE's nuclear waste program, especially its continued reliance upon salt and salt formations for future repositories. On February 12th, the President announced that the DOE would accelerate its efforts to locate, characterize, and develop a number of potential sites for geologic repositories in several different kinds of geologic media other than salt before a final site would be selected. This policy, based upon the recommendations of the Interagency Review Group on Nuclear Waste Management, reflects the advice of the U.S. Geological Survey, the NRC, the National Academy of Sciences, and many independent scientists.

The DOE has repeatedly stated that it is redirecting its research efforts toward non-salt media and sites. However, a close look at the DOE program and the waste program budget indicates that little has changed. DOE is giving serious consideration to only two non-salt sites: the Nevada Test Site and the Hanford Reservation. Activities at the Nevada Test Site have already lead to the disqualification of potential granite, argillite, and shale sites leaving only the the volcanic tuff site at Yucca Mountain still under consideration. Although DOE is exploring a number of potential sites for basalt, these are limited to the Hanford Reservation.

DOE has proposed a substantial total increase of $54,165,000 in its waste isolation program ostensibly to expand non-salt exploration activities, however, 46% of that increase or $24,876,000 is for additional work at salt sites. While DOE has developed only the two potential non-salt locations, it is currently examining multiple sites in each of the following salt geology areas: Gulf Coast Salt Domes, Salina Basin, Paradox Basin, and the Permian Region. DOE does not believe that under the current program it can identify a non-salt site, except for the Nevada Test Site, before FY 1983 or FY 1984.

Given the President's policy, and one which the Environmental Policy Center believes is sound, to chose the best site from among four or five potential sites in different geologic media, more funds should be redirected away from research and development of salt formation sites and shifted to non-salt activities. Included in these changes should be the $21 million request for the development of the Waste Isolation Pilot Plant(WIPP)near Carlsbad, New Mexico and the $6.8 million request for a salt formation test facility. DOE, in the second phase of its basalt test facility is only requesting $3,576,000, while asking for almost twice that amount for an as yet unidentified salt facility for which the design is not yet completed. This salt test facility is estimated to cost upwards of $20 million to $30 million and should be deferred until the DOE can give a better accounting of the purpose of the facility and its relationship to the proposed work at the WIPP which it would duplicate.

Funds diverted from salt formation activities should be channeled into the DOE-USGS national systems screening program to develop suitable site criteria and potentially acceptable regions without regard to whether they are "on the reservation". It should be noted that the uranium resource assessment program, although substantially reduced this year to $35.8 million, has been operating at a budget of approximately $65 million. The goals of this program, of identifying and locating selective geologic formations, are comparable to that required of a comprehensive nuclear waste site selection effort. We recommend that the systems screening program receive significantly more funding on the order of that given the uranium resource assessment program.

DOE's commercial waste programs for high-level waste and waste treatment technology parallel often identical programs under DOE's defense waste program. For example DOE has had a commercial waste program to develop disposal technology for transuranic wastes although there is not commercial reprocessing now taking place which would require this technology, nor will there be any in the near future. While DOE has requested $4,750,000 for FY 1981 for this program, the DOE defense program is spending $25 million per year under the same Albuquerque Operations Office oversight to develop the same transuranic waste disposal technology. Similar duplication occurs in the low-level waste programs and in high-level waste technology programs where both programs are aimed at developing vitrified waste forms. The Appropriations Committees should make every effort to eliminate this duplication and consolidate these programs in the commercial program where appropriate. Increased attention should be paid to airborne waste immobilization in both defense and commercial programs as evidenced by the need to handle the krypton gas at Three Mile Island .

In closing, I would like to call the Committee's attention to the magnitude of the various remedial action programs, which DOE estimates will cost approximately $50 million to $70 million per year perhaps through the year 2000. This program will obviously become quite expensive and every effort should be made to encourage recovery of these costs from parties who can be determined to be liable as allowed under the Uranium Mill Tailings Radiation Control Act of 1978. Finally, I wish to express our continued opposition to the Administration's proposal to shift the responsibility for the storage of commercial spent fuel to the public sector. The technology is commercially available, it is licenseable by the NRC, its economics are well understood. I direct the Committee's attention to DOE's recent update of utility requirements(DOE/NE-0002).

STATEMENT BY
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A recent budget action by OMB, has placed in jeopardy the advancement of a new clean coal technology.

In August 1979 DOE issued Program Opportunity Notices (PON's") seeking contracts for fluidized bed combustion boiler demonstrations in industry, on a cost-sharing basis. This program was correctly motivated in the belief that a few well selected installations would better convince industry of the compatibility of this non-pollution coal technology in a range of industrial settings. Responses were received from representative companies of major industries (e.g. steel, chemicals, paper) and DOE expected to negotiate contracts during early 1980.

This new demonstration program was to have been funded by an appropriation of $4.3 million in FY 1980 and an authorization request of $9.8 million FY 1981. In its review of the DOE proposed 1981 budget, OMB deleted the FY 1981 request for this program. The entire program will have to be scrapped, and no contracts with industry will be negotiated.

We are appalled by this decision, particularly in the light of the 1978 Fuel Use Act, designed to move industry (and utilities) on to coal as quickly as possible. Further, it does not square with the many assurances given by the Administration that all possible measures to encourage increased coal utilization will be taken.

Fluidized combustion represents the first clean coal burning technology to emerge in answer to this nation's energy crisis. But it needs government support to allay the concerns of industrial users who are reluctant to be pioneers.

We urge that action be taken by the Senate to restore FY 1981 funds for the continuance of this program.